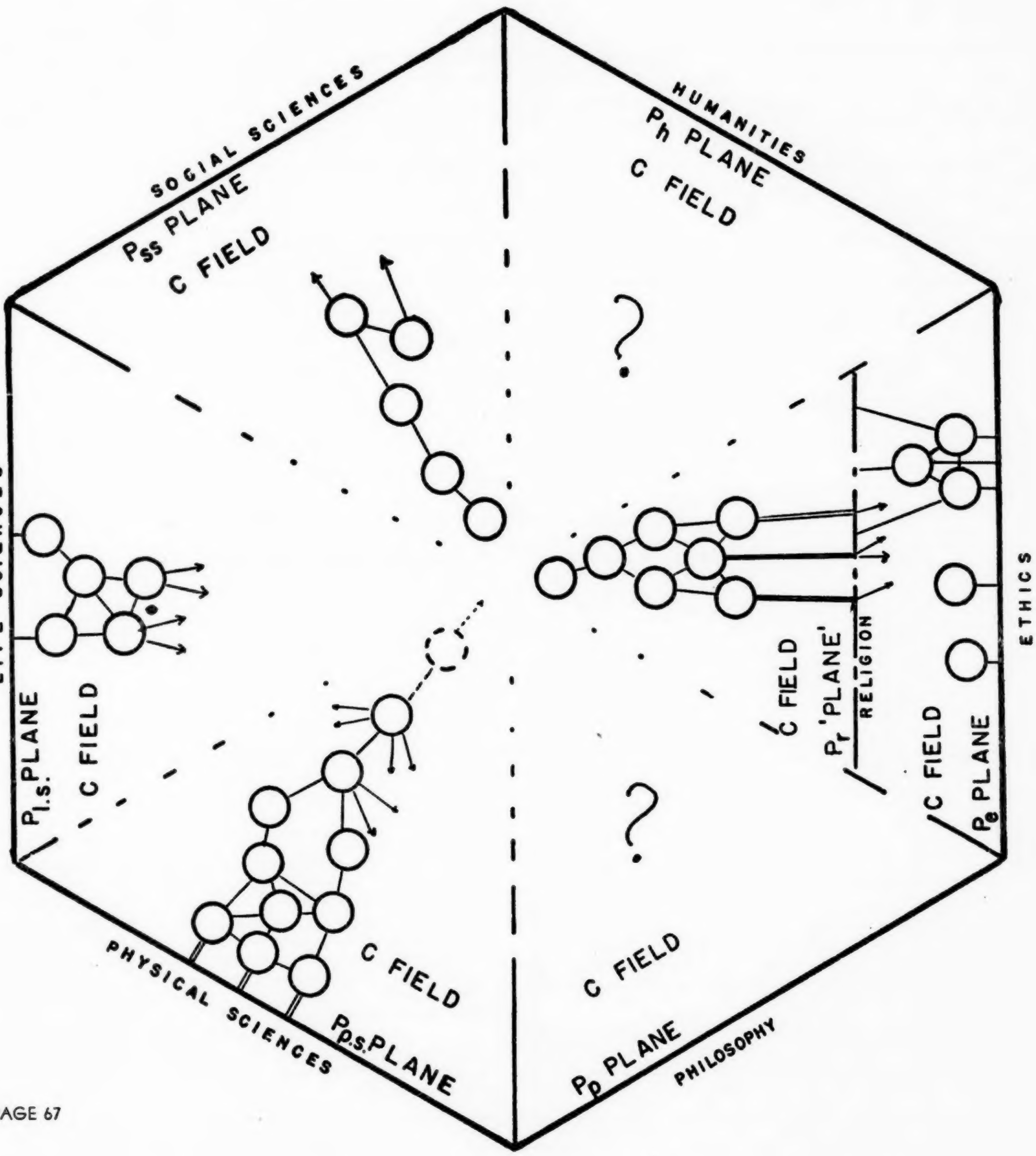
MAIN CURRENTS

IN MODERN THOUGHT



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VOL. 9 NO. 3

MAIN CURRENTS IN MODERN THOUGHT

A co-operative journal to promote the free association of those working toward the integration of all knowledge through the study of the whole of things, Nature, Man, and Society, assuming the universe to be one, dependable, intelligible, harmonious.

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"Ah, but a man's reach should exceed his grasp, or what's a heaven for?" — BROWNING

CONTENTS

AIMS OF THE FOUNDATION FOR INTEGRATED EDUCATION

The Foundation is incorporated under the laws of the State of New York as a non-profit educational organization. Contributions are tax deductible.

The corporate statement of Aims declares that the Foundation has been established:

1. To collect, create, and distribute authoritative materials which will encourage the development of unified overall concepts in education; to improve the balance of relationships between the physical sciences and the social sciences; to inquire into the phenomena of purposive activity in nature, man and the universe.

2. To assist teachers to understand and use such materials, and to develop an active, realistic, comprehensive philosophy which will communicate to their students the unity, coherence, and beauty of the world in which we live.

3. To remedy, solely by such educative measures, the conceptual and hence the ethical, social, economic, and political breakdown of our times, looking to a peaceful world order.

The members, associates, and staff of the Foundation realize that the progressive discovery of unifying over-all concepts concerning man and the universe is not a task to be performed successfully in isolation from the historical, social, economic, and political context of our times, nor in terms of application less than global.

The work of the Foundation is wholly educational, yet is referred constantly to the contemporary scene in all its aspects, no less than to the total available wealth of human experience and knowledge.

MAIN CURRENTS IN MODERN THOUGHT is published 4 times a year to call attention to significant contributions to learning currently being made by workers in the multiple fields into which knowledge has come to be classified. It relates these advances to each other and to the classical and contemporary views of Eastern, European and American thinkers. It is designed to save time for the reader by providing a vantage-ground from which the whole world of knowledge may be surveyed and kept in proportion as it moves toward integration. Its editors assume that the principles of art, the universals of philosophy, the laws of Nature and Man as formulated by science, and the truths of comparative religion, can be orchestrated into a harmonic, meaningful, ethical body of teachings which can and should be made the central core of curricular study in the educative process at all levels of development. In condensing text, square brackets [ ] indicate editorial interpolation. Three dots . . . in the text indicates a word, phrase or passage omitted in the interest of brevity or clarity. Other usages are standard. $3.00 a year. Foreign $3.50. Contributors to MAIN CURRENTS enjoy full liberty of opinion and expression in these pages. *to whom all communications regarding MAIN CURRENTS IN MODERN THOUGHT should be addressed. Entered as second class matter April 13th, 1946, at the post office at Port Chester, New York, under the Act of March 3rd, 1879.*

THE METHODOLOGY OF PHYSICS EXTENDED TO OTHER FIELDS

John A. Day

Oregon State College

The Relation of Ethics and Religion To Developments in Modern Science

Introduction

The belief that there exists a "conflict" between science and ethics, and between science and religion, is one of the major obstacles in the way of a true integration of knowledge. Such a belief can be maintained only by those who look superficially at these fields of human endeavor. A careful analysis of the basic method of science reveals a deep affinity between science and other aspirations of our race. This paper is devoted to an exposition of common features in these divergent fields, and arguments are advanced to show that ethics and religion lie, in a sense, beyond the horizon of modern science but that they are within its reach when this horizon expands.

Henry Margenau makes the following statement in summarizing what he deems to be the nature of physical reality: ". . . most of our human experience . . . with its sense of duty, freedom, responsibility is at present neutral to the established concerns of [physical][1] reality. But no prediction was made that they will remain forever neutral *to the principles by which physical existence sustains itself*."[2] This is a statement which has tremendous implications. He would seem to imply that we are at the threshold of serious attempts to extend the methodology of the physical sciences into the realms of the social sciences and ethics. The recent workshop of the Foundation for Integrated Education[3] served to apprise the participants of the progress which is being made in this direction through efforts of individuals like Dr. Stuart Dodd and Dr. Margenau, who work in the fields of sociology and physics, respectively.

In this paper the writer ventures out into the unexplored regions and attempts to extend Margenau's approach into additional areas of human experience. The results, obviously incomplete at this stage, seem to possess unifying inferences, which in turn have ramifications that bear on the current problems of higher education.

Glossary

Certain terms will be used in the text of this paper which may not be understood by the reader in the exact context intended by the writer. Therefore a limited glossary will be presented at this somewhat unusual place for purposes of clarification.

Ethics — the philosophy of human conduct with emphasis on the determination of right and wrong.

Religion — one's serious consideration of, and concern with, those things which affect the quality and destiny of human existence.

Philosophy — a body of principles underlying a given branch of learning.

Metaphysics — a term tending to designate two large branches of thought: epistemology and ontology; a group of epistemological postulates of relatively enduring structure.

Epistemology — the methodology of the cognitive processes.

Ontology — the science of real being; the philosophical theory of reality.

Theory — an attempt at the explanation of a group of related facts.

P Plane : C Field Conceptual Scheme

Margenau represents physical reality as made up of two aspects: first, a plane of perception, the p-plane,

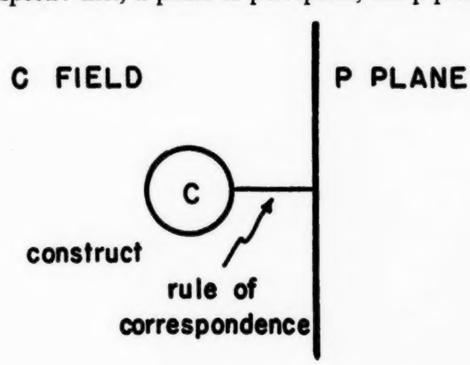


FIG. 1

[1] Brackets and italics are the writer's.

[2] Margenau, Henry, *The Nature of Physical Reality*, McGraw-Hill, New York, 1950, p. 448.

[3] Workshop held on Oregon State College campus June 23-28, 1952.

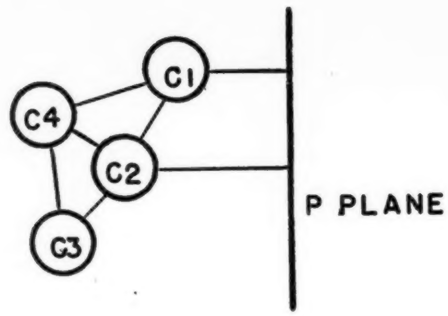


FIG. 2

which is our immediate perception or awareness of nature as it impinges upon us,[4] and second, a three-dimensional field of constructs, the c-field, in which are imbedded our ideas about the nature of reality. The field of constructs is related to the perceptual plane by so-called rules of correspondence. These rules serve as "channels of communication" between c-field and p-plane. They oftentime take the form of operational definitions. Every construct which is measurable must be linked to the p-plane by such an operational definition or "recipe." For example, force becomes a measurable quantity when linked to the p-plane by the operational definition which is commonly called Newton's Second Law.

Some constructs are not directly related to the p-plane. Yet, if valid, they must be linked by logical mathematical relationships to other constructs, one or more of which are linked by a rule of correspondence to the p-plane.

Constructs can be considered a part of physical reality if they stand up to the test of empirical verification and satisfy a certain set of metaphysical requirements. The former can be illustrated by going back to the time of Galileo and Newton. Galileo started on the p-plane with certain data, namely observations of falling bodies, and went from this into the realm of constructs. There the constructs of mass and acceleration were found to be so related that he was able to predict the results of experiments dealing with falling bodies having different masses. Newton, extending Galileo's reasoning, related the construct of force with the constructs of mass and acceleration in such a way that many successful circuits of empirical confirmation from the p-plane through the c-field and back to a new point on the p-plane were made possible.

[4] This is considered to be two dimensional because of the lack of analytic depth peculiar to perception.

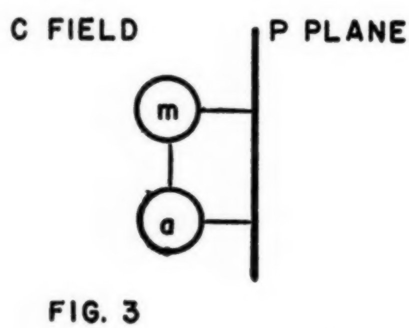


FIG. 3

Metaphysical Requirements

Margenau suggests that the several metaphysical requirements that pertain to the constructs of science first emerge in the stream of experience as tentative expedients, grow into implicit beliefs with increasing application, and finally, strengthened by repeated success, pervade the entire texture of our theories about the world.[5] In his view these principles are not to be considered as immutable. They may change very slowly, any slight change giving rise to a profound modification in the detailed structure of science.

Any construct that occupies a respectable place in the structure of science must "come up with flying colors" after having been subjected to the test of the following six requirements:

A. *Logical Fertility*. This requirement implies that constructs should be formulated in such a way as to permit logical manipulation, and so that they obey logical laws.

B. *Multiple Connections*. These may be of two types —formal or epistemic. The former sets a construct in a purely logical relation to another construct, e.g., Newton's laws are related to force and acceleration, and Einstein's law of General Relativity is related to the curvature of space and the quantity of mass in the universe. The latter arises from and is equivalent to a rule of correspondence which links a construct with data in nature, such as a house and the vision of it, or a force and the awareness of muscular exertion. This requirement might be shown graphically thus (see below):

[5] *Op. cit.* p. 81.

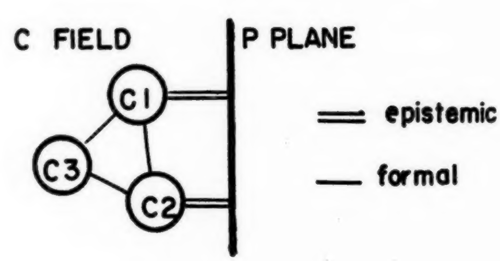


FIG. 4

The requirements are that those constructs which are admissable in science may not be insular or peninsular, and "island universes" must be excluded. This simply means that those constructs which are to be valid and accepted in natural science must be related to others so that there can be passage from one in at least two ways to others. Margenau quotes the construct of the "color" of an electron as being peninsular, since there seems to be no way of substantiating it.

C. *Permanence and Stability.* This requirement implies that over the lifetime of a given theory, the elements making up that theory may not be altered arbitrarily to fit the investigator's convenience. If modifications are required by virtue of compelling new empirical evidence, then only the new rules shall apply, and not an *ad lib* mixture of new and old.

D. *Extensibility of Constructs.* A scientist judges the correctness of a theory partially by the range of its application and its generality. For example, if Newton's theories had been applicable only to apples and not to stones, planets, and stars, they would probably have been discarded soon. The wide acclaim of the theory of Universal Gravitation is due to its extensibility. Einstein, in his theory of General Relativity, attempted to show how gravitation was a particular instance of a still more extensible construct, the curvature of space-time.

E. *Causality.* This is viewed by Margenau as a relation that exists between states of physical systems in which a given state is invariably followed in time by another specified state. If state A, *then* state B. If B follows A sufficiently often, then a casual law is considered to exist.

This requirement says that constructs be chosen so as to generate causal laws.

Margenau points out that Heisenberg and Born, eminent modern physicists, have shown what strange and unexpected properties the states of systems must possess to be causally related.

F. *Simplicity.* The greatest men of science e.g., Kepler, Planck, Einstein, etc. have been fervent advocates of this requirement. Einstein's $E=mc^2$, relating energy, mass and the speed of light is a classical example. If there are two theories presented, both of which adequately explain the data, the decision of science is in favor of the theory possessing simplicity. The victory of the Copernican over the geocentric theory of astronomy illustrates the case.

The Approach Illustrated in Physics

Let us illustrate the methodology of science with a limited example from physics (fig. 5).

A particular nexus has been chosen showing the multiple connections out to C-10, the General Theory of Relativity, one of the most far reaching theories as yet propounded which occupies a valid position in the structure of science. Responding to the urge for complete knowledge the search continues for some "Unified Field Theory," represented as C-11, which will relate all known physical phenomena.

From whence do these constructs come? "As inspiration from the mind of a genius," says Margenau.

Before leaving this example in physics let us push even beyond C-10 and C-11 into the realm of ultimates and ask, "Is there a source of the energy in the Universe?" According to the scheme we have developed, any postulate in science is at first a tentative assertion. Therefore there should be no objection to the assertion that "There is a single source." A glimpse of the nature of such a construct could be obtained by logical reasoning from the set of metaphysical requirements previously presented, i.e., to the highest degree it should be simple, widely extensible, multiply connective, etc. To be sure, any circuit of empirical confirmation as we know it in the physical sciences would be difficult, if not impossible, to achieve. But may we not have crossed over into a realm where confirmation is by other means than by measurement as it is customarily understood in physics?

Extension to Ethics and Religion

In another publication[6] Margenau has given some attention to the application of these general methods of approach in the realm of ethics. Briefly, his argument is that in ethics there is also a field of con-

[6] "Remarks on Ethical Science," *The Nature of Concepts, Their Inter-Relation and Role in Social Structure,* proc. the Stillwater Conference, pub. by Oklahoma A. & M. College, 1950, and sponsored jointly by the Foundation for Integrated Education.

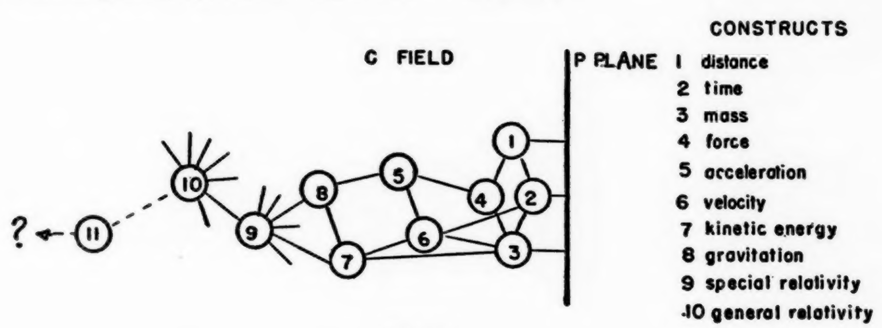


FIG. 5

structs. These constructs take the form of sets of norms for human conduct such as the Ten Commandments. Confirmation on the P (ethics) Plane would be in terms of certain criteria applicable to large groups of people who lived according to a particular set of norms. For example, if, in a certain population, there was an abnormally low percentage of mentally ill, social life was stable, and other such criteria were met, it might be said that the particular set of norms by which the group lived was consistent with the nature of reality.

In attempting to represent religion and ethics by a similar method it should be borne in mind that the perceptual plane differs with each area of human experience, i.e., we don't attempt to measure right conduct with a spring balance, nor the correctness of a physical theory by our conscience.

Religion and ethics are intimately connected. The codes of ethics found in different civilizations have their origins in religion or in perversions of religion. A considerable diversity of ethical norms is to be found around the world. This would seem to be related to the fact that religion evolves from primitive to enlightened forms, and to the virility of particular forms of religion.

The manner in which religion and ethics are connected is shown in the figure below. In the C (ethics) Field certain constructs which we have indicated are sets of ethical norms are shown linked by the appropriate rules of correspondence to the P (ethics) Plane where they are subject to confirmation by the appropriate criteria.

Beyond the C Field of ethics, it seems to the writer, there lies what we might call the P Plane of religion (P(r) Plane). This "plane" extends at the juncture of individual man's experience with his God. The man who has this experience then projects it "outward" to the P (ethics) Plane where it becomes measurable in terms of the various criteria which may have been set up. In the case of some individuals the P(r) Plane may be very close to the P(e) Plane. There has been no conscious awareness or acknowledgment of the existence of God other than through a general adherence to and acceptance of a set of ethical norms which stemmed originally from a man's intimate experience of God. In the case of others[7] the experience may be a profound and a continual awareness of the Living God. For the latter the P(r) Plane would be represented as in closer proximity to the basic constructs in the C(r) Field.

It seems to the writer that empirical confirmation of the validity of the constructs set up in the field of religion would have to be primarily on the P(e) Plane. If the basic constructs in the C(r) Field were invalid, it would not be possible to go through any successful circuit of empirical confirmation in the field of ethics.

If we were to consider Christianity, one of the great world religions, some of the basic constructs dealing with the nature of God are those of a *Father,* who *loves* (in the sense of the Greek *agapé*) men, who *judges* the moral conduct of men yet who offers forgiveness for human frailties in terms of His *grace*.

The constructs of other great religions differ in certain respects, resulting in certain differences in sets

[7] The extremes being great mystics such as Jesus, St. Francis, Buddha, Mohammed, etc.

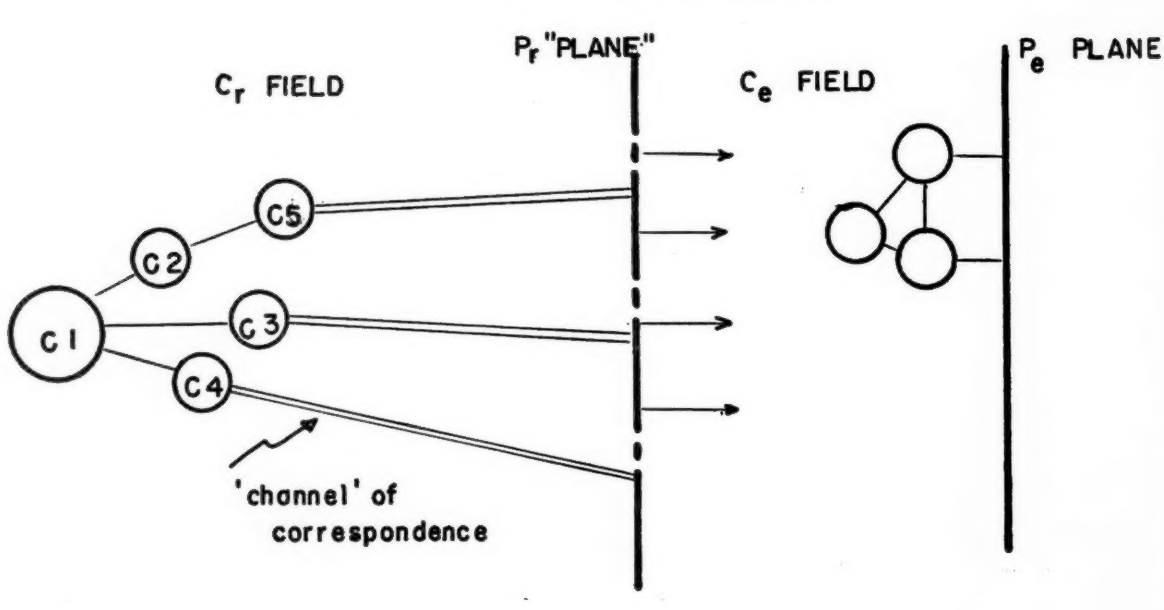


FIG. 6

of ethical norms. Rules of correspondence and verification procedures might also differ. Yet, perhaps one principle of verification common to all would be to measure what happens to the human personality as it lives according to the various sets of ethical norms.

What is the origin of these basic constructs in ethics and religion? What, for example, was the original of the Decalogue? If we accept the Biblical answer, it was given to Moses by God, the liberal translation of which would be that this set of ethical norms came to a man's mind as a penetrating insight into one aspect of reality. What was the origin of the construct of God having the attribute of a loving Father? Once again, a postulate which human experience seems to verify as a penetrating insight into one aspect of reality. It is interesting to note that the answer to our question, "What was the origin . . . ?" is similar to that which we found in posing the same question in the physical sciences.

Further Extensions

The major emphasis of this paper has been given over to consideration of two extremes: religion and ethics, and physical science. One of the intermediate disciplines which is being treated by this method is that of the social sciences.[8] Here there would be a nexus involving group relationships related to the P(ss) Plane by a particular set of rules of correspondence and confirmed by measuring instruments such as the demoscope.[9]

A relationship of various disciplines in juxtaposition is shown in the cover illustration.

[8] Refer to various writings of Dr. Stuart Dodd, U. of Wash. Public Opinion Lab.

[9] A sociological measuring device: the public poll and all its facets.

Summary

We note in the cover illustration that there is cellular division between disciplines only at the perimeter, the divisions rapidly fading away toward the center. We also note a convergence toward the center.

It is possible to encircle the most basic constructs near the center and say, "Here we have fashioned a set of constructs which tell us something of the basic nature of reality."

The "believer" may choose to name this reality "God." The "non-believer" will draw his own inferences, but he should do so with the reminder that the methodology of physics says that the simplest theory which explains the most facts in the most coherent fashion is the one which is accepted, and used.

We conclude with a significant statement by Max Planck:[10]

> Looked at correctly science is a self-contained unity; it is divided into various branches, but this division has no natural foundation and is due simply to the limitations of the human mind which compel us to adopt a division of labor. Actually there is a continuous chain from physics and chemistry to biology and anthropology and thence to the social and intellectual sciences; a chain which cannot be broken at any point save capriciously. Again the methods used in the various branches are found to have strong inner resemblance, if closely considered, and if they appear to differ it is only because they have to be adapted to different subjects which they treat. This inner resemblance has become more and more evident in recent time, to the great advantage of the whole of science.

[10] Planck, Max, *The Philosophy of Physics*, New York; Norton, 1936, 87-88.

RESONANCE FOR THE STUDENT OF LIBERAL ARTS

John Hamaker

Whittier College

This paper by a professor of chemistry was presented at the Foundation's Corvallis Workshop, June, 1952. It develops the concept of resonance as a possible link between the physical sciences and the humanities. The presentation was deliberately scaled to be simple enough for groups with virtually no technical background.

Resonance, in its strict formulation as a tool of technical chemistry and physics, has commanded little interest for those not practicing in either field. However the general idea of resonance, treated as an integral part of our thought, is widespread in our culture. We would do well to connect these general ideas with the recent developments in chemistry and physics.

At the Montecito conference of the Foundation for Integrated Education, Professor Malcolm Stewart of Illinois College stated his conviction that we greatly needed methods of thought which would deal with things as wholes. This he regarded as a major philosophic problem of the present time. The analytical approach, so well perfected, is at a disadvantage in dealing with unbroken wholes. We can readily dissect a man's body and name all

the parts, but it is not so easy to think about the living organism as a whole and the living state. Physiology and psychology, insofar as they are sciences of the whole man, should be able to use methods of thought capable of dealing more satisfactorily with unbroken wholes. We have, therefore, a topic in hand which has very timely importance in many fields.

Thus far we have been speaking of resonance without a referent. The basic idea behind the word can be explained in three stages: first, the common usage of the word, as in acoustics; second, the principle of resonance more precisely drawn; and third, resonance as used in quantum or wave mechanics.

In the first sense, resonance means just what it says—re-sound—and deals with the reflection and reinforcement of sound. A rough example of it is the sounding board of the piano, reflecting and augmenting the sound from the piano string. The sound given off by a vibrating string without a "resonator" is very faint indeed. The hollow box body of the violin and of other string instruments adds volume, and the trained singer arches his chest and drops his jaw for the same reason.

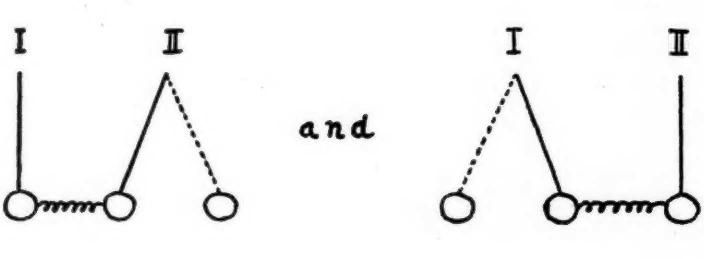
The above rough approximation is intended only to give an orientation. To get a more adequate idea of the principle of resonance, perform the following experiment: Stand before a piano and strike a note, middle C, for instance. Next depress the same key gently, merely lifting the hammer from the string, and sing middle C loudly. When you stop and listen, you will hear that same note faintly sounding in the piano. Sing a note a little higher or lower and there will be no response. From this we can draw a more precise idea of resonance. The string has a certain rate of vibration that is natural to it, 256 per minute in the case of middle C. When plucked, the string, vibrating at this frequency, gives off sound at the pitch of middle C. Sounding the note D will not set the string C in motion, because D's natural rate is not the frequency for C.

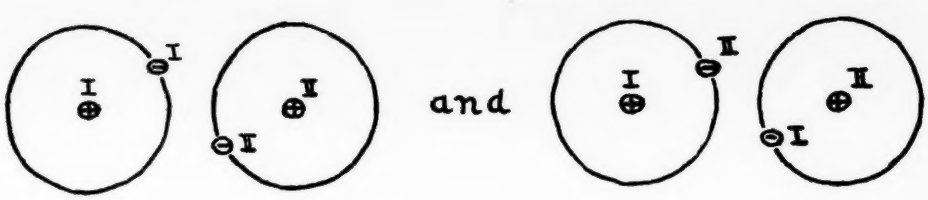
This principle is not limited to musical instruments. Many natural objects have their particular sets of natural vibration frequencies. When we have a note which corresponds to one of these, the object or some part of it will begin to vibrate. We then say we have resonance. Reports occasionally appear of a singer who finds the natural note of a glass and then by singing that note very loudly breaks the glass. The term applies to the rattle among the glasses when a certain note sounds on the radio, or the tendency of a car to rattle at certain speeds. Nor is the phenomenon restricted to sound, as radio uses the same principle. A circuit can vibrate electrically in response to radio waves, so tuning the radio is merely a matter of bringing the radio circuit into resonance with the radio waves of a particular station.

It is all too easy to move from the resonance of acoustics directly to human experience. The question of aesthetic appreciation seems to have some elements suggestive of resonance. In my personal experience, I find I must attain a certain set of mind and feeling to appreciate a given composer. There are some, of course, with whom I have no response. It is as if there were a tuning process involved, and this suggests that a man could be regarded as a resonator in certain circumstances. Sympathy then becomes a human quality resembling a hollow sounding box, or other machinery. All this may have its place, but I am proposing a less superficial inquiry.

Before we discuss resonance in modern physical chemistry, let us, as stage two, examine a familiar experiment. Imagine two pendulums of about equal mass suspended side by side and connected by a weak spring. One pendulum only is placed in motion in a direction parallel to the connector. A fascinating phenomenon will be observed. Gradually as time passes, the first pendulum will slow down and the second will swing more and more until the first has become stationary and all the motion is in the second pendulum. Then the process will repeat itself, returning the motion to the first pendulum, and the cycle will start anew. This phenomenon also is called resonance, referring to the oscillation of energy back and forth between the two pendulums. It will arise whenever two vibrators are suitably coupled or linked. When two tuning forks of the same pitch are placed side by side the same thing will occur. If one tuning fork is struck, the energy of vibration will oscillate back and forth, first one then the other fork vibrating. Here the coupling is not a mechanical spring but the trains of sound waves sent out by the fork. We must realize that this is a closed and complete system which varies between two conditions:

In the first, pendulum II is swinging and in the other, pendulum I is swinging.





We must here emphasize a major point: Regarding the set-up *as a whole* is in general more fruitful than to regard it as two pendulums tied together. Thus regarded, it is a *system,* something very different than a concatenation of parts.

Let us imagine two hydrogen atoms next to each other, each consisting of a proton (positively charged particle) with an electron spinning around it. We now have two possible situations between which the system of two hydrogen atoms can alternate (fig. above).

The atoms can swap electrons back and forth, which is resonance, and which, in this case, can be interpreted as constituting a force of attraction between the two atoms. (We ignore the antisymmetric state.)

Thus it is that at last the chemist arrives at a rational picture for the fact that hydrogen atoms *do* go about in pairs, and so must attract each other. The hydrogen molecule is a very stable molecule, attesting to the strength of this attractive force. Moreover, since other kinds of atoms also possess electrons, a basis is laid for understanding many of the chemical attractions. It is explained why two hydrogen atoms and one oxygen atom combine to form H_2O (water), or 12 carbon atoms, 22 hydrogen atoms, and 11 oxygen atoms combine to form $C_{12}H_{22}O_{11}$ (sugar), or 6 carbon atoms and 6 hydrogen atoms combine to form C_6H_6 (benzene). Shall we say all are held together by pairs of confused electrons who don't know where they belong?

One further example will show the power of this idea in the field of chemistry. Let us consider the structure of benzene, modifying our picture by drawing a single line between atoms to represent a pair of binding electrons. A pair of lines will represent two pair or four electrons acting to tie the two atoms together. Thus we find, with the structure which chemists have decided upon, that there are two possible arrangements (fig. below).

Here again there is resonance, and the effect is to make the molecule more stable, harder to decompose. That it was more stable than should be expected from the structure was known early by the chemists, but only with the development of this concept of resonance did any reason appear. This reason is that the binding electrons which give the added force constitute the whole into a functional system, or one might say (again) that the molecule is held together much more firmly by a bunch of confused electrons who don't even know between which pair of atoms they belong.

From these examples it should be clear that the idea of resonance is very useful to the chemist and physicist. For others the significant point is that resonance is an idea to deal with the inadequacy of looking upon molecules, pairs of pendulums, or tuning forks as collections of parts. Following a careful analysis of our pair of spring-connected pendulums, Pauling says,[1] "It is clear from this analysis that we speak of resonance only because it is convenient for us to speak of the pendulums individually rather than of the system as a whole." In other words, the system should be treated as a whole, and if we treat it as a collection of interacting parts, we leave something out, something that resonance enables us to restore to the system. Shall we call it a principle of unity?

This is even more true of atoms. The pair of hydrogen atoms actually forms a total unified system, and to regard it as being still two atoms omits

[1] Pauling, Linus, and Wilson E. B., ***Introduction to Quantum Mechanics,*** McGraw-Hill, 1935, p. 7.

-A- -B-

the essential totality. We then have to recognize the two possible structures and invoke the idea of resonance. The two states between which we regard the hydrogen molecule as resonating are not representative of the condition of the molecule. Its true state (we again ignore the antisymmetric state as being unstable) is sometimes called a resonance hybrid and is more stable than either of the two possibilities pictured. The only reason we use resonance is that we cannot picture the hybrid, as that involves sacrificing our mental set that the hydrogen atoms retain their identity. Also the exact treatment of the system as a whole is often too complex for our present mathematics, and it is possible to fall back upon the approximate treatment, plus resonance, to get a usable answer.

The meaning of all this seems to be the old adage that the whole is more than the sum of its parts, and that we do need to introduce a missing factor of the totality if we are to get a realistic picture of any system which we insist on seeing as composed of parts. This we can do in the case of simple systems of atoms and molecules. Have we the mental tools to do the job with human groups, animal societies, and the many other systems we meet with in our environment? Perhaps we need to know a good deal more about the social atom, man himself, before we can be fully successful with holism at that level.

There is one direction in which the resonance idea seems to have had an effect on our thinking. I refer to the growing dissatisfaction with the "either or" logic. The idea of resonance indicates another point of view: that a state is possible in which we are not reduced to choice between extremes, but can resolve the two. Thesis and antithesis are to be taken as two parts of a whole, the synthesis, in Hegel's terminology. We thus arrive at a more stable and more meaningful situation than either alone can provide.

SCIENCE AND COMPLEXITY

Warren Weaver

Rockefeller Foundation

The Scope of Modern Knowledge — And Its Boundaries

Science has led to a multitude of results that affect men's lives. Some of these results are embodied in mere conveniences of a relatively trivial sort. Many of them, based on science and developed through technology, are essential to the machinery of modern life. Many other results, especially those associated with the biological and medical sciences, are of unquestioned benefit and comfort. Certain aspects of science have profoundly influenced men's ideas and even their ideals. Still other aspects of science are thoroughly awesome.

How can we get a view of the function that science should have in the developing future of man? How can we appreciate what science really is and, equally important, what science is not? It is, of course, possible to discuss the nature of science in general philosophical terms. For some purposes such a discussion is important and necessary, but for the present a more direct approach is desirable. Let us, as a very realistic politician used to say, let us look at the record. Neglecting the older history of science, we shall go back only three and a half centuries and take a broad view that tries to see the main features, and omits minor details. Let us begin with the physical sciences, rather than the biological, for the place of the life sciences in the descriptive scheme will gradually become evident.

Problems of Simplicity

Speaking roughly, it may be said that the seventeenth, eighteenth, and nineteenth centuries formed the period in which physical science learned variables, which brought us the telephone and the radio, the automobile and the airplane, the phonograph and the moving pictures, the turbine and the Diesel engine, and the modern hydroelectric power plant.

The concurrent progress in biology and medicine was also impressive, but that was of a different character. The significant problems of living organisms are seldom those in which one can rigidly maintain constant all but two variables. Living things are more likely to present situations in which a half-dozen, or even several dozen quantities are all varying simultaneously, and in subtly interconnected ways. Often they present situations in which the essentially important quantities are either non-quantitative, or have

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at any rate eluded identification or measurement up to the moment. Thus biological and medical problems often involve the consideration of a most complexly organized whole. It is not surprising that up to 1900 the life sciences were largely concerned with the necessary preliminary stages in the application of the scientific method—preliminary stages which chiefly involve collection, description, classification, and the observation of concurrent and apparently correlated effects. They had only made the brave beginnings of quantitative theories, and hardly even begun detailed explanations of the physical and chemical mechanisms underlying or making up biological events.

To sum up, physical science before 1900 was largely concerned with two-variable *problems of simplicity;* whereas the life sciences, in which these problems of simplicity are not so often significant, had not yet become highly quantitative or analytical in character.

Problems of Disorganized Complexity

Subsequent to 1900 and actually earlier, if one includes heroic pioneers such as Josiah Willard Gibbs, the physical sciences developed an attack on nature of an essentially and dramatically new kind. Rather than study problems which involved two variables or at most three or four, some imaginative minds went to the other extreme, and said: "Let us develop analytical methods which can deal with two billion variables." That is to say, the physical scientists, with the mathematicians often in the vanguard, developed powerful techniques of probability theory and of statistical mechanics to deal with what may be called problems of *disorganized complexity.*

This last phrase calls for explanation. Consider first a simple illustration in order to get the flavor of the idea. The classical dynamics of the nineteenth century was well suited for analyzing and predicting the motion of a single ivory ball as it moves about on a billiard table. In fact, the relationship between positions of the ball and the times at which it reaches these positions forms a typical nineteenth-century problem of simplicity. One can, but with a surprising increase in difficulty, analyze the motion of two or even of three balls on a billiard table. There has been, in fact, considerable study of the mechanics of the standard game of billiards. But, as soon as one tries to analyze the motion of ten or fifteen balls on the table at once, as in pool, the problem becomes unmanageable, not because there is any theoretical difficulty, but just because the actual labor of dealing in specific detail with so many variables turns out to be impracticable.

Imagine, however, a large billiard table with millions of balls rolling over its surface, colliding with one another and with the side rails. The great surprise is that the problem now becomes easier, for the methods of statistical mechanics are applicable. To be sure the detailed history of one special ball cannot be traced, but certain important questions can be answered with useful precision, such as: On the average how many balls per second hit a given stretch of rail? On the average how far does a ball move before it is hit by some other ball? On the average how many impacts per second does a ball experience?

Earlier it was stated that the new statistical methods were applicable to problems of disorganized complexity. How does the word "disorganized" apply to the large billiard table with the many balls? It applies because the methods of statistical mechanics are valid only when the balls are distributed, in their positions and motions, in a helter-skelter, that is to say a disorganized, way. For example, the statistical methods would not apply if someone were to arrange the balls in a row parallel to one side rail of the table, and then start them all moving in precisely parallel paths perpendicular to the row in which they stand. Then the balls would never collide with each other nor with two of the rails, and one would not have a situation of disorganized complexity.

From this illustration it is clear what is meant by a problem of disorganized complexity. It is a problem in which the number of variables is very large, and one in which each of the many variables has a behavior which is individually erratic, or perhaps totally unknown. However, in spite of this helter-skelter, or unknown, behavior of all the individual variables, the system as a whole possesses certain orderly and analyzable average properties.

A wide range of experience comes under the label of disorganized complexity. The method applies with increasing precision when the number of variables increases. It applies with entirely useful precision to the experience of a large telephone exchange, in predicting the average frequency of calls, the probability of overlapping calls of the same number, etc. It makes possible the financial stability of a life insurance company. Although the company can have no knowledge whatsoever concerning the approaching death of any one individual, it has dependable knowledge of the average frequency with which deaths will occur.

This last point is interesting and important. Statistical techniques are not restricted to situations where the scientific theory of the individual events is very well known, as in the billiard example where there is a beautifully precise theory for the impact of one ball on another. This technique can also be applied to situations, like the insurance example, where the individual event is as shrouded in mystery as is the chain of complicated and unpredictable events associated with the accidental death of a healthy man.

The examples of the telephone and insurance companies suggest a whole array of practical applications of statistical techniques based on disorganized complexity. In a sense they are unfortunate examples, for they tend to draw attention away from the more fundamental use which science makes of these new techniques. The motions of the atoms which form all matter, as well as the motions of the stars which form the universe, come under the range of these new techniques. The fundamental laws of heredity are analyzed by them. The laws of thermodynamics. which

describe basic and inevitable tendencies of all physical systems, are derived from statistical considerations. The entire structure of modern physics, our present concept of the nature of the physical universe, and of the accessible experimental facts concerning it rest on these statistical concepts. Indeed, the whole question of evidence and the way in which knowledge can be inferred from evidence are now recognized to depend on these same statistical ideas, so that probability notions are essential to any theory of knowledge itself.

Problems of Organized Complexity

This new method of dealing with disorganized complexity, so powerful an advance over the earlier two-variable methods, leaves a great field untouched. One is tempted to oversimplify, and say that scientific methodology went from one extreme to the other — from two variables to an astronomical number — and left untouched a great middle region. The importance of this middle region, moreover, does not depend primarily on the fact that the number of variables involved is moderate—large compared to two, but small compared to the number of atoms in a pinch of salt. The problems in this middle region, in fact, will often involve a considerable number of variables. The really important characteristic of the problems of this middle region, which science has as yet little explored or conquered, lies in the fact that these problems, as contrasted with the disorganized situations with which statistics can cope, show the essential feature of *organization*. In fact, one can refer to this group of problems as those of *organized complexity*.

What makes an evening primrose open when it does? Why does salt water fail to satisfy thirst? Why can one particular genetic strain of microorganism synthesize within its minute body certain organic compounds that another strain of the same organism cannot manufacture? Why is one chemical substance a poison when another, whose molecules have just the same atoms but assembled into a mirror-image pattern, is completely harmless? Why does the amount of manganese in the diet affect the maternal instinct of an animal? What is the description of aging in biochemical terms? What meaning is to be assigned to the question: Is a virus a living organism? What is a gene, and how does the original genetic constitution of a living organism express itself in the developed characteristics of the adult? Do complex protein molecules "know how" to reduplicate their pattern, and is this an essential clue to the problem of reproduction of living creatures? All these are certainly complex problems, but they are not problems of disorganized complexity, to which statistical methods hold the key. They are all problems which involve dealing simultaneously with a *sizeable number of factors which are interrelated into an organic whole*. They are all, in the language here proposed, problems of *organized complexity*.

On what does the price of wheat depend? This too is a problem of organized complexity. A very substantial number of relevant variables is involved here, and they are all interrelated in a complicated, but nevertheless not in helter-skelter, fashion.

How can currency be wisely and effectively stabilized? To what extent is it safe to depend on the free interplay of such economic forces as supply and demand? To what extent must systems of economic control be employed to prevent the wide swings from prosperity to depression? These are also obviously complex problems, and they too involve analyzing systems which are organic wholes, with their parts in close interrelation.

How can one explain the behavior pattern of an organized group of persons such as a labor union, or a group of manufacturers, or a racial minority? There are clearly many factors involved here, but it is equally obvious that here also something more is needed than the mathematics of averages. With a given total of national resources that can be brought to bear, what tactics and strategy will most promptly win a war, or better: what sacrifices of present selfish interest will most effectively contribute to a stable, decent, and peaceful world?

These problems—and a wide range of similar problems in the biological, medical, psychological, economic, and political sciences — are just too complicated to yield to the old nineteenth-century techniques which were so dramatically successful on two-, three-, or four-variable problems of simplicity. These new problems, moreover, cannot be handled with the statistical techniques so effective in describing average behavior in problems of disorganized complexity.

These new problems, and the future of the world depends on many of them, require science to make a third great advance, an advance that must be even greater than the nineteenth-century conquest of problems of simplicity or the twentieth-century victory over problems of disorganized complexity. Science must, over the next 50 years, learn to deal with these problems of organized complexity.

Is there any promise on the horizon that this new advance can really be accomplished? There is much general evidence, and there are two recent instances of especially promising evidence. The general evidence consists in the fact that, in the minds of hundreds of scholars all over the world, important, though necessarily minor, progress is already being made on such problems. As never before, the quantitative experimental methods and the mathematical analytical methods of the physical sciences are being applied to the biological, the medical, and even the social sciences. The results are as yet scattered, but they are highly promising. A good illustration from the life sciences can be seen by a comparison of the present situation in cancer research with what it was twenty-five years ago. It is doubtless true that we are only scratching the surface of the cancer problem, but at least there are now some tools to dig with and there have been located some spots beneath which almost surely there is pay-dirt. We know that certain types of cancer can be induced by certain pure chemicals.

Something is known of the inheritance of susceptibility to certain types of cancer. Million-volt rays are available, and the even more intense radiations made possible by atomic physics. There are radioactive isotopes, both for basic studies and for treatment. Scientists are tackling the almost incredibly complicated story of the biochemistry of the aging organism. A base of knowledge concerning the normal cell is being established that makes it possible to recognize and analyze the pathological cell. However distant the goal, we are now at last on the road to a successful solution of this great problem.

In addition to the general growing evidence that problems of organized complexity can be successfully treated, there are at least two promising bits of special evidence. Out of the wickedness of war have come two new developments that may well be of major importance in helping science to solve these complex twentieth-century problems.

The first piece of evidence is the wartime development of new types of electronic computing devices. These devices are, in flexibility and capacity, more like a human brain than like the traditional mechanical computing device of the past. They have "memories" in which vast amounts of information can be stored. They can be "told" to carry out computations of very intricate complexity, and can be left unattended while they go forward automatically with their task. The astounding speed with which they proceed is illustrated by the fact that one small part of such a machine, if set to multiplying two ten-digit numbers, can perform such multiplications some 40,000 times faster than a human operator can say "Jack Robinson." This combination of flexibility, capacity, and speed makes it seem likely that such devices will have a tremendous impact on science. They will make it possible to deal with problems which previously were too complicated, and, more importantly, they will justify and inspire the development of new methods of analysis applicable to these new problems of organized complexity.

The second of the wartime advances is the "mixed-team" approach of operations analysis. These terms require explanation, although they are very familiar to those who were concerned with the application of mathematical methods to military affairs.

As an illustration, consider the over-all problem of convoying troops and supplies across the Atlantic. Take into account the number and effectiveness of the naval vessels available, the character of submarine attacks, and a multitude of other factors, including such an imponderable as the dependability of visual watch when men are tired, sick, or bored. Considering a whole mass of factors, some measurable and some elusive, what procedure would lead to the best over-all plan, that is, best from the combined point of view of speed, safety, cost and so on? Should the convoys be large or small, fast or slow? Should they zigzag and expose themselves longer to possible attack, or dash in a speedy straight line? How are they to be organized, what defenses are best, and what organization and instruments should be used for watch and attack?

The attempt to answer such broad problems of tactics, or even broader problems of strategy, was the job during the war of certain groups known as the operations analysis groups. Inaugurated with brilliance by the British, the procedure was taken over by this country, and applied with special success in the Navy's anti-submarine campaign and in the Army Air Forces. These operations analysis groups were, moreover, what may be called mixed teams. Although mathematicians, physicists, and engineers were essential, the best of the groups also contained physiologists, biochemists, psychologists, and a variety of representatives of other fields of the biochemical and social sciences. Among the outstanding members of English mixed teams, for example, were an endocrinologist and an X-ray crystallographer. Under the pressure of war, these mixed teams pooled their resources and focused all their different insights on the common problems. It was found, in spite of the modern tendencies toward intense scientific specialization, that members of such diverse groups could work together and could form a unit which was much greater than the mere sum of its parts. It was shown that these groups could tackle certain problems of organized complexity, and get useful answers.

It is tempting to forecast that the great advances that science can and must achieve in the next fifty years will be largely contributed to by voluntary mixed teams, somewhat similar to the operations analysis groups of war days, their activities made effective by the use of large, flexible, and highspeed computing machines. However, it cannot be assumed that this will be the exclusive pattern for future scientific work, for the atmosphere of complete intellectual freedom is essential to science. There will always, and properly, remain those scientists for whom intellectual freedom is necessarily a private affair. Such men must, and should, work alone. Certain deep and imaginative achievements are probably won only in such a way. Variety is, moreover, a proud characteristic of the American way of doing things. Competition between all sorts of methods is good. So there is no intention here to picture a future in which all scientists are organized into set patterns of activity. Not at all. It is merely suggested that some scientists will seek and develop for themselves new kinds of collaborative arrangements; that these groups will have members drawn from essentially all fields of science; and that these new ways of working, effectively instrumented by huge computers, will contribute greatly to the advance which the next half century will surely achieve in handling the complex, but essentially organic, problems of the biological and social sciences.

The Boundaries of Science

Let us return now to our original questions. What is science? What is not science? What may be expected from science?

Science clearly is a way of solving problems—not all problems, but a large class of important and practical ones. The problems with which science can deal are those in which the predominant factors are subject to the basic laws of logic, and are for the most part measurable. Science is a way of organizing reproducible knowledge about such problems; of focusing and disciplining imagination; of weighing evidence; of deciding what is relevant and what is not; of impartially testing hypotheses; of ruthlessly discarding data that prove to be inaccurate or inadequate; of finding, interpreting, and facing facts, and of making the facts of nature the servants of man.

The essence of science is not to be found in its outward appearance, in its physical manifestations; it is to be found in its inner spirit. That austere but exciting technique of inquiry known as the scientific method is what is important about science. This scientific method requires of its practitioners high standards of personal honesty, open-mindedness, focused vision, and love of the truth. These are solid virtues, but science has no exclusive lien on them. The poet has these virtues also, and often turns them to higher uses.

Science has made notable progress in its great task of solving logical and quantitative problems. Indeed, the successes have been so numerous and striking, and the failures have been so seldom publicized, that the average man has inevitably come to believe that science is just about the most spectacularly successful enterprise man ever launched. The fact is, of course, that this conclusion is largely justified.

Impressive as the progress has been, science has by no means worked itself out of a job. It is soberly true that science has, to date, succeeded in solving a bewildering number of relatively easy problems, whereas the hard problems, and the ones which perhaps promise most for man's future, lie ahead.

We must, therefore, stop thinking of science in terms of its spectacular successes in solving problems of simplicity. This means, among other things, that we must stop thinking of science in terms of gadgetry. Above all, science must not be thought of as a modern improved black magic capable of accomplishing anything and everything.

Every informed scientist, I think, is confident that science is capable of tremendous further contributions to human welfare. It can continue to go forward in its triumphant march against physical nature, learning new laws, acquiring new power of forecast and control, making new material things for man to use and enjoy. Science can also make further brilliant contributions to our understanding of animate nature, giving men new health and vigor, longer and more effective lives, and a wiser understanding of human behavior. Indeed, I think most informed scientists go even further and expect that the precise, objective, and analytical techniques of science will find useful application in limited areas of the social and political disciplines.

There are even broader claims which can be made for science and the scientific method. As an essential part of his characteristic procedure, the scientist insists on precise definition of terms and clear characterization of his problem. It is easier, of course, to define terms accurately in scientific fields than in many other areas. It remains true, however, that science is an almost overwhelming illustration of the effectiveness of a well-defined and accepted language, a common set of ideas, a common tradition. The way in which this universality has succeeded in cutting across barriers of time and space, across political and cultural boundaries, is highly significant. Perhaps better than in any other intellectual enterprise of man, science has solved the problem of communicating ideas, and has demonstrated the world-wide cooperation and community of interest which then inevitably results.

Yes, science is a powerful tool, and it has an impressive record. But the humble and wise scientist does not expect or hope that science can do everything. He remembers that science teaches respect for special competence, and he does not believe that every social, economic, or political emergency would be automatically dissolved if "the scientists" were only put into control. He does not—with a few aberrant exceptions—expect science to furnish a code of morals, or a basis for aesthetics. He does not expect science to furnish the yardstick for measuring, nor the motor for controlling, man's love of beauty and truth, his sense of value, or his convictions of faith. There are rich and essential parts of human life which are alogical, which are immaterial and non-quantitative in character, and which cannot be seen under the microscope, weighed with the balance, nor caught by the most sensitive microphone.

If science deals with quantitative problems of a purely logical character, if science has no recognition of or concern for value or purpose, how can modern scientific man achieve a balanced good life, in which logic is the companion of beauty, and efficiency is the partner of virtue?

In one sense the answer is very simple: our morals must catch up with our machinery. To state the necessity, however, is not to achieve it. The great gap, which lies so forebodingly between our power and our capacity to use power wisely, can only be bridged by a vast combination of efforts. Knowledge of individual and group behavior must be improved. Communication must be improved between peoples of different languages and cultures, as well as between all the varied interests which use the same language, but often with such dangerously differing connotations. A revolutionary advance must be made in our understanding of economic and political factors. Willingness to sacrifice selfish short-term interests, either personal or national, in order to bring about long-term improvement for all must be developed.

None of these advances can be won unless men understand what science really is; all progress must be accomplished in a world in which modern science is an inescapable, ever-expanding influence.

THE SEAMLESS GARMENT

Herbert E. Childs

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(This is the text of the principal address at a dinner held in honor of two retiring members of the English department at Oregon State College on May 27, 1952. The speaker refers to the 1952 Workshop of the Foundation for Integrated Education held on the campus June 23 to 28, 1952.)

My title is "The Seamless Garment," and I take my text from the Gospel according to St. John, from the 23rd verse of the 19th Chapter: ". . . now the coat was without seam, woven from the top throughout." You will shortly perceive that I am in good, or rather, bad company, namely, the company of those who quote Scripture for a purpose. I am going to use the text to help perpetrate a heresy.

Let me state the heresy all at once, so that you may see its wickedness fully revealed. According to my creed, education is a seamless garment. It is all of one piece. All knowledge is interrelated. Any one portion of knowledge assumes the existence of all the other parts and cannot be separated from the other parts without loss both to itself and to the other parts. If I were founding a university, there would be no schools and no departments, only broadly trained scholars each of whom would also be a specialist in one of the major disciplines.

If a scholar is to have any lasting effect on the world, if he is ever going to be more than just another of the numberless pedagogues who have harried the young ever since the time of the Sophists, he must be a man, like Plato, like William James, like Kittredge, who can get out of his own field. The limitations which hinder us from crossing departmental lines are in us, not in our subjects.

It is commonly realized nowadays that those who study the structure of the atom are physicists, chemists, and mathematicians all at the same time. I wish to dwell for a few moments on the part of the seamless garment usually called the humanities. My idea can be summed up in the following propositions: 1. Knowledge of one of the humanities presupposes fairly intimate knowledge of the other humanities, particularly philosophy. 2. Knowledge of the humanities requires more than a nodding acquaintance with the social studies. 3. Knowledge of the humanities and the social studies requires knowledge of the basic concepts and methods of the physical and biological sciences.

There you have my heresy in all its awfulness.

It has been announced that the 1952 workshop of the Foundation for Integrated Education will meet on this campus from June 23 to 28 of this year. In spite of the unfortunate associations of that word "integrated," here would appear to be a step in the right direction. This, we are told, is an attempt "to estimate the content and to discuss the application of the methods of the physical sciences to other subjects." Among the other subjects named are biology, sociology, and the humanities. These examples make us pause for a moment to realize that while the humanities are not ordinarily considered in the same breath with the physical sciences, and sociology is sometimes only rather gingerly connected with the sciences, even biology is not, narrowly speaking, accounted a physical science. But among its methods is that of mathematical measurement, as in physics. It is but a step from biology to sociology, though the measurement here is commonly by the questionnaire method. Take one step further and you are in psychology — first, if you like, making a half-step into social psychology. And from psychology where can you step but into literature and philosophy, which are the center of the humane studies?

In education, then, as Emerson said of things in general,

> All are needed by each one;
> Nothing is fair or good alone.

The common subject of all studies is man and his place in the universe. The methods of the various disciplines differ, sometimes in degree, sometimes in kind. Some studies appear to be further from the center than others, but the distance may be only a temporary illusion. No method of investigation is wholly futile, and no fact is wholly lost. Education is one. A dozen examples leap to mind; I omit most of them for lack of time.

It is fashionable at conventions of scholars in literature to object to the arrogant and ignorant self-centeredness of the physical and biological scientists, or to the almost unreadable monographs of the social scientists. It is also fashionable to complain about the current lessening of interest in the humanities — such facts as were documented by Dr. Benjamin Fine in the March 9, 1952 issue of the *New York Times.* (Of course in these complaints what the complainer usually means is that fewer students are now enrolling in his own courses.) After the complaints have been aired in the corridors and the section meetings, all the complainers assemble at the general meeting on the final evening to hear some high priest of literature utter the great affirmation: "We believe in the humane studies; we believe that when men truly realize the value of literature, literature will come again into its own; the humanities will never be destroyed," and so on. And by such whistling past the graveyard each lesser priest is encouraged to return to the classroom and the six bewildered students studying the prose of Matthew Arnold.

Of course this affirmation is true. Even the Nazis, the supreme bad example of a society by

and for technicians, though they made the humane studies subserve evil ends, could not deny their own common humanity. Because we are all human, the humane studies will never wholly cease to exist.

But I submit that we have had enough complaints from English teachers, language teachers, history teachers. Surely some of the fault must lie in ourselves. It is time to examine our own shortcomings, to eliminate them, and to bring the humanities back to the center of education so that our students may join us there.

Our first shortcoming is historical pedantry. It is not wrong to study the history of literature. It *is* wrong to overvalue one's own special topic and not see its true place in the whole scheme of historical studies. I offer as instances any meeting of the Modern Language Association of America, or, probably, the doctoral dissertation of everyone in this room who has written a dissertation. If this were an experience meeting I would offer my own as the first horrible example. Only by overcoming the handicap of the Ph.D. do we become successful teachers.

The secondary deficiency I shall call adherence to is the Chicago orthodoxy. Certain famous men now or lately connected with the University of Chicago hold that we can unify education by adopting the philosophy of neo-scholasticism. The goal is a right goal; the route they would have us follow will never bring us there.

A third of our deficiencies is excessive aestheticism. Twenty years ago this tendency was represented by a group called the New Humanists. Nowadays some of the survivors of this group and a host of younger scholars call themselves Formalists and are called by their enemies New Critics. Much of their creed consists of a sane redirection of our attention back to a close examination of the actual work of art under discussion and not just of the facts about the work of art. Both the New Humanists and the Formalists claim to consider man as a part of man. But both start from an outmoded 18th century psychology of dualism. They fail to see that human and animal cannot be separated, or, rather, that man's so-called "human" accomplishments are the result of an exceedingly complex nervous system that differs from the nervous system of the other animals only in its complexity — a difference of degree, not of kind. The end-result is to set up art as a structure separate from life, remote from the American people, and seemingly almost wholly irrelevant to the young in our colleges.

The fourth shortcoming I have already touched on. It is departmentalization. The humanities are one. The humanities and the social sciences are one. And when did the natural sciences cease to be among the humane studies?

Let me give one example of the evil of departmentalization. Does the President of the United States possess such implied powers that he may seize control of the steel mills in time of emergency? The answer is "yes, under certain carefully specified conditions." Where do we find this answer? Not in the law, which is a social science. Judging by the news reports, counsel for the United States treated the question as a legal question only, and so served the President ill. The late great Justice Holmes, who had read John Stuart Mill, would never have been satisfied with the mere legalities. The answer to the question is found in at least three of the humanities: in deductive logic, in American history (probably the most pertinent precedent is Lincoln's suspension of *habeas corpus* during the Civil War), and in some of those parts of political theory which are included in the domain of literature, and that means almost all parts of political theory.

The moral to be extracted from this example must be that lawyers should be trained in the humanities and, conversely, that other citizens, including the President of the United States, ought to have a general citizen's knowledge of the law and the other social sciences plus the humanities plus the natural sciences. Indeed, almost all the public statements on the steel case, from the top down, simply betray the speaker's ignorance.

Let me briefly speak of one example of how, willy-nilly, specialists have had to broaden their researches into several related fields.

Semantics, a study that began some thirty years ago, was first confined to the field of language and literature and is still an important tool in the interpretation of literary works. But the semanticists almost immediately found that they were deep in psychology, that is, first in verbal psychology and then in a mechanistic psychology depending on non-verbal formulations; thence they were forced to plunge into mathematics because they had to get into symbolic logic; and thus they were in epistemology, a division of philosophy. It is difficult to see how anyone could now study any of these without studying the others unless, that is, he takes a purely parochial and departmentalized view of the world.

Our dean once said something to the effect that the finest occupation of all is to be a professor of English. It would be difficult to convince most outsiders that this is so, but he was absolutely right. Perhaps these, our retiring colleagues, whom we honor tonight, and who have spent many years in the service of language and literature, will testify out of their rich wealth of experience that the dean was correct. In some ways being a professor of English is a frustrating life, but our old friends probably discovered long ago that one of the best means of ignoring the frustration is to realize that literature touches all of life, and all of life touches literature. Or, to recur to the original metaphor, when we recognize that literature occupies a central position in education, we perceive that education is indeed a coat "without seam, woven from the top throughout."

INTEGRATIVE CONCEPTS IN SCIENCE, PHILOSOPHY, EDUCATION

Some of the Major Integrative Concepts Presented In the Course, "The Frontier of Knowledge"

We publish below compressed accounts of certain major aspects of the last eight lectures in the Spring, 1952, term of the New York University course, "The Frontier of Knowledge: Integrative Concepts in Science, Philosophy, and Education." The form of expression here given to the arguments is (because of excessive reduction) not necessarily that of the speakers. Accounts of the first term lectures were published in Vol. 8, No. 4, and of the first seven in the second term in Vol. 9, No. 2.

Verbatim lecture reports have been prepared and will, under certain conditions, be made available as part of the cooperative program on the frontier of knowledge which the Foundation for Integrated Education offers.

Lecture VIII. Philosophies of Education, Dr. Theodore Brameld, Professor of Education, New York University.

The traditional way to classify philosophies of education has been in terms of the traditional philosophic categories of idealism, realism, pragmatism, perhaps eclecticism, and scholasticism, but that has not proved altogether effective. Another way has been to use labels invented by the philosophers of education themselves: essentialism, progressivism, etc. These also may not be altogether satisfactory. I would like to attempt tonight a tentative experiment in classification of educational philosophy.

When one asks the question, "How can the philosophies of education help to clarify the meaning of integration of knowledge?" it may be we can get most help from what is a comparatively new discipline, culturology. Culturology is the discipline concerned with the meaning of culture. It is necessarily, therefore, concerned with education because very clearly education is deeply concerned with culture. We find there is not one theory of culture but several of them.

I am going to outline four theories of culture in necessarily very superficial form: (1) the metaphysical theory; (2) the epistemological theory; (3) the experimental theory; and (4) the sociological theory. As representative of these theories, I have chosen for (1) the cyclical theory represented by Oswald Spengler in *Decline of the West.* I will attempt to develop (2) with the aid of Fritz Cassirer's symbolic theory of culture. The pragmatic theory of culture represented by John Dewey will exemplify (3), and the ideological utopian theory of Carl Mannheim will represent (4).

There are certain similarities among all four theories. All recognize the irrational, emotional, reflective, intuitional side of life side by side with the reflective and theoretical side of life. All four also would agree that a philosophy of history is essential to a philosophy of culture. They would agree that culture changes and evolves, that concepts and values are to some degree relative to culture. Finally, they would agree with some of the philosophy of science experts earlier in this course that there is a certain propriety to the expectation of universality in scientific postulations and law, provided that those postulations, if universal, are at the same time regarded as historical and subject to modification in terms of further research and cultural evolution.

As to differences among the four, it might be argued that the cyclical and symbolic theories of Spengler and Cassirer are more systematic and rich with content than are the other two, which are not so much detailed content studies as rich methods by which culture may be understood and controlled. Spengler and Cassirer tend on the whole to hold a deductive theory of culture. They tend to believe with a good many qualifications that a system of formal concepts built into a philosophy of culture determines the nature of culture. On the other hand, Dewey and Mannheim tend to hold an inductive theory in which they believe culture itself and man as an agent of culture tend to explain the nature of philosophy and of the conceptual world.

The first two tend to believe philosophy is self-determinative of the nature of culture, and the last two that culture is primarily determinative of the nature of philosophy.

We are left with the question still unsettled as to which of these philosophies to accept. I would imagine that is not a question we can settle. But if we are to develop an effective theory of integration of knowledge, we must first recognize that there are several theories of integration which must be clarified and compared.

Lecture IX. The Meaning of Good Behavior, Dr. Clyde Kluckhohn, Director, Russian Institute, Harvard University.

One of the things which all human cultures have in common is a set of standards of good behavior. This and many other facts about the human species show that in spite of the gamut of variation in behavior as between individuals and behavior as characteristic of certain groups, the variation is neither completely boundless nor is it in any sense

random. Human life is and has to be a moral life, precisely because it is a social life and because in our kind of animal the necessities of social life are not taken care of by instincts, as they are with some of the social insects.

We are all aware that in detail conceptions of good behavior are not identical as between different peoples or even among the same people at different periods in their history. But I submit that from the point of view of integrated education clearly differentiated standards of good behavior are certainly no more important than the broad similarities.

What is the meaning of good behavior from the standpoint of the individual? There has been a kind of over-emphasis upon adjustment as the criterion of good behavior. Many of us have taken it to mean a complete surrender to the somewhat abstract and statistical standards of our society. While change and novelty are of great value to us, we Americans are by and large the most conformist of all people in the Western world to the standards of our own particular age, occupational group, etc. Little is said about a criterion of good behavior which in other cultures is very highly developed: the criterion of internal harmony, the self-realization of the potentialities of an individual as a unique biological organism with a unique life history. Yet, on the whole, the judgment of humanity of rich culture is that the meaning of good behavior so far as the individual is concerned is a sufficient conformity to make cooperation in social life possible but without sacrifice of internal harmony of the personality, with spontaneous behavior which comes out of the whole personality. This is what some psychiatrists call the full value of personality, the personality which has achieved right balance between self-expression, personal creativity, and participation with others toward common goals and by common customs.

From the standpoint of the group, what is the meaning of good behavior? In spite of variation in time and place, human beings on the whole have agreed to certain criteria.

In all cultures there is something wrong with the behavior of an individual who is permanently or over long periods of time rather consistently inaccessible to communication with his fellows. Also, all societies agree that an indispensable criterion of good behavior is a certain minimum amount of control over one's impulse life. No culture tolerates indiscriminate lying, stealing, or violence. The essential universal of the incest taboo is well known. We know of no culture, including Soviet Russia, where the official ideology denies an afterlife, where the fact of death is not ceremonialized. The value, "Thou shalt not kill thy fellow tribesman," is not completely identical for different cultures, but the central conception is the same.

Certainly some values are relative to specific cultures, but there is a generalized framework that underlies the more apparent and striking facts of cultural relativity. All cultures constitute so many distinct answers to essentially the same questions posed by human biology, physical world generalities of the human situation. Every society's patterns for living must provide approval and sanctioned ways for dealing with such universal circumstances as the existence of two sexes, the helplessness of infants, the need for satisfaction of the elementary biological requirements such as food, warmth, and sex, the presence of individuals of different ages and different physical and other capacities.

The facts of human biology and human gregariousness supply, therefore, certain variant points of reference from which cross-cultural comparison can start.

It is possible that changed circumstances in the human situation may lead to the gradual disappearance of some of the present universals. However, the mere existence of universals after so many millennia of human history and in such diverse environments suggests that they correspond to something extremely deep in man's nature and/or are necessary conditions to human life. Any science must be adequate to explain both the similarities and the differences in the phenomena with which it deals. Recent anthropology has focussed its attention too much upon the differences. They are there, they are real, they are important, though they are still so many variations on universal themes supplied by not only human nature, but the nature of the world in which human beings live. The common understanding between men of different cultures is very broad, very general, very easily obscured by language, and by their observable symbols. Universals do seem to be relatively few in number, but they seem to be as deep going as they are rare.

Lecture X. Scientific Bases of Ethics, Dr. Margenau.

First let us assume that there are some types of ethics which are not scientific. One of these is ethics based upon "fright." This type is found abundantly among primitive peoples with their taboos. It also occurs in our own culture when we are asked, even by religion, to be good for the sake of some reward or punishment either in this life or in an after life. Another type of unscientific ethics is that which is based upon or presumes the absolute. But the scientist has a certain humility about ever finding the absolute and we have amply proved that the scientific method does not yield ultimate or absolute truth.

Science delivers a sort of dynamic, self-correcting truth which can never be ultimate. Here one encounters the question, "Is the good ultimate and should it be ultimate?"

One kind of scientific ethic supposes that ethical good can be gleaned from anthropological observation. According to this view, ethical behavior is the

de facto behavior of man and the de facto can be raised to de jure by fiat. Another scientific ethic claims that if one accumulates the content of the various scientific disciplines he will be an ethical individual. Both of these are erroneous, in my opinion. Ethical norms cannot be drawn from the actual behavior of men and I doubt that there is any chance of extracting ethical codes from the facts of science. There is a lack of continuity somewhere as one passes from science, which is a descriptive, explanatory discipline, to ethics, which is normative. Something else must be introduced.

While it may be impossible to engender norms on the basis of scientific principle, it may be possible that ethics, as a discipline, can have the formal structure of a science. I would like to see ethics partake of some of the qualities of the scientific method which sets up rules of correspondence which permit us to go from the field of immediate perception to the field of constructs and back again. Science has been successful because of the concatenation of the immediacies in our experience with certain logical entities or conceptual ideas and the ever-present possibility of a return to nature in the field of perception.

The scientist begins with postulates as his ultimates. From these he draws certain logically restricted inferences. Pushing this process of explication further and further, he comes to a proposition which he can test directly upon the p-plane, or nature. If all the tests succeed, he speaks of the postulates as true. But notice that the validity of postulates is only a reflection upon their logical status by a multitude of immediate experiences and observations. The scientist does not demand absolute certainty with respect to the validity of his postulates and he does not expect divine accreditation for them. This stage of explication, of deriving useful constructs from more or less vague, abstract initial postulates is the sort of thing one learns in school. Postulation of scientific norms is, however, not taught in schools as it requires the brains of genius and the experience of the mature scientific man.

The third phase of scientific method is that of verification. Verification is not as obvious and easy as it would appear as it involves the large complicated artifact of the theory of errors to determine whether the observations do or do not validate the postulates.

Ethics starts also with postulates called norms of behavior. These cannot be given a priori proof although the religious man wishes to have divine certification for them at the very beginning. Why should we be more unreasonable in our demands with respect to ultimate ethical norms than with the postulates of science?

The practice of explication in ethics is just as important as it is in science. We educators have quite generally failed to seize the opportunity of explaining ethical norms to children in terms of their daily lives. Ethics is taught wholly differently from science. We teach the laws of arithmetic as though they were absolutely true, never allowing children to have any doubts as to their validity. We teach ethics in a haphazard way.

In science, propositions can be verified. But there must be principles of verification. In science these principles are called inductive logic.

The same principles should apply to ethics. A few can be named. Survival may be a crude but unfailing method of verification. Hedonism is not a code of behavior but a principle of verification. Categorical imperatives, too, in my opinion, cannot be used as a code of behavior but can only act in conjunction with norms as principles of verification. The confusion in ethics springs far more from ignorance with respect to fundamental methodology than from the unavailability of norms or principles of verification. Then, too, as science has advanced there has been a shift in the process of verification from individual instances to statistical averages. I infer that in ethics, too, it takes a whole group or society to verify a code.

Most attempts at analyzing ethics stop with a recital of values and nothing much of benefit has been the result. Why? Values cannot be regarded as absolutes since they are the human attitude with respect to norms. Change your norms and you will change the whole structure of values. Education can generate or destroy values. Therefore, instead of starting with an analysis of values we might better start with an analysis of norms. Every perception may be regarded as a fact but facts are inspired with significance only by their relevance to ideas, to postulates. In the same way, values are given significance by their relevance to postulates.

Are ethical standards relative or absolute? The scientist who understands the physical theory of relativity will tell you that the lawfulness of that theory is most unique and comes perhaps as near to absolute truth as is humanly possible. It has a generality, a logical force possessed by very few scientific principles, and it demands complete allegiance to certain postulates. Certainly it gives no comfort to those who would use it to prove that standards are relative. Scientists speak of the principle of uniformity in nature and accept it in one form or another in all parts of science. This principle operates to deny relativism in ethical application. If we follow its lead, we arrive at the clear decision that standards do not permit altered and variform interpretations under different circumstances. Norms of ethics, according to this view, should also be respected without exception.

But scientific axioms do change in time as the scientist continues to learn about his universe. As we have seen, this self-regulating dynamism is one of the remarkable features of scientific progress. If I read the implications aright, and accept the attitude of scientific ethics, it teaches a lesson that ethics, too, should temper its insistence upon eternal truth and endeavor to review and alter a time-honored standard when such a review becomes necessary. Relativism is not the term to describe such changes. Dynamism is the term which I would prefer.

Lecture XI. Democracy and Social Action, Dr. Sidney Hook, Professor of Philosophy, New York University.

In considering the present subject, I shall discuss three main topics: (1) the nature of democracy, (2) the justifications of democracy, and (3) the implications of democracy for social action.

Democracy may be defined as a society in which the major decisions of government are based upon the freely given consent of the adult governed. The key term is "freely given consent," and we may ask, "What are the conditions under which this is present?" Some of the obvious conditions are absence of coercion, whether physical, or economic, or through denial of access to knowledge. The main test for the existence of a democracy is the presence of a legally recognized opposition with opportunities provided for any minority to become or to represent the majority. Thus a democracy is a form of government in which is manifested an equality of concern for all human beings. The world we know is one in which human beings are equal.

But as men are not equal intellectually or physically, on what grounds do we justify democracy when it is challenged as a way of life? Four generic types of justifications can be offered. The first is the religious; the second, metaphysical; the third, natural scientific; and fourth, empirical scientific.

The religious justification takes many forms but is in general based on such beliefs as the brotherhood of man under the fatherhood of God; that because all men are equal before God, they should treat one another equally. The metaphysical justification maintains that the nature of ultimate reality requires a belief in the validity of democratic society; that if we knew the fundamental nature of man we could discover the good society. But whatever the nature of ultimate reality, the answer to the question, should we organize ourselves democratically, must still be found, and we must look for the evidence not in metaphysics or theology, but in the domain of experience.

The third type of justification suggests that we look for the evidence in the field of tested knowledge: the field of natural science. The view is that insight into the physical, chemical, or biological order of the universe will give agreement about the nature of the good society. It seems obvious to me that not all the knowledge in the world about the facts of physical nature can determine the specific social uses to which we put these facts.

Having disposed of these three forms of justification, can we justify democracy? I believe it is possible to offer an empirical justification in terms of method rather than in terms of doctrine. My contention is that democracy permits us to achieve more of value, interest, and satisfaction than either a despotic or anarchic society. We take it as a hypothesis that democracy is more valid than other systems, and test it against problems one at a time. By so doing we can reach conclusions that are reliable without being certain. This involves an assumption that we don't have to accept: that all human beings must be able to agree on the same values. I leave it an open question whether we can't find we have enough interests in common so that we can extend them and so cultivate a kind of tolerance to each other. Perhaps we shall never get an assurance of universal morality by this method, but we shall always live in the possibility of such a morality.

Suppose we justify democracy, what are the limits of social action in a democracy? Access to knowledge involves provision for the presentation of points of view different from those generally accepted. The right to heresy is part of the belief in democracy, but the right to heresy does not carry with it the right to conspiracy. Confusion between these two is the basis of most confusion today about the limits of social action. No democracy can survive unless it respects heresy and discourages conspiracy.

Lecture XII. Philosophy of Science, Morals, and Democratic Policy, Dr. George Axtelle, Professor of Education, New York University.

I should like to begin this evening's discussion of the general problem of values by noting some agreements and differences with previous lecturers. Professor Northrop suggested that value attitudes are importantly influenced by one's conception of things; Professor Hook insisted that general metaphysical outlook has little to do with values. On this point I agree with Northrop. I would agree with Margenau and Hook, however, in the assertion that value judgments can be validated, where validation consists of a process by which a value claim is subjected to analysis and empirical tests.

I should like to identify a few terms as I shall use them. The terms "good" and "bad" I take to be psychological, as they refer to what people may like or dislike. If we consider validation verification, the term value refers to a course of action or an object which satisfies a value claim which has been validated. There are two kinds of good, intrinsic and extrinsic or instrumental. I think it is impossible for any good to be either intrinsic or instrumental or both: every intrinsic good is to be judged not merely by the satisfaction it gives but by the satisfaction it leads to. The possibility of a democratic society rests upon the possibility that every value claim must show its credentials, and these must be empirical tests.

In the process of evaluation, there are three factors: (1) the person, personal interest, bias; (2) cultural modalities, norms, customs; (3) validation. So long as the first, personal inclination, conforms to the cultural norms, there is no value problem. Life is rarely that simple, however, as our desires are not always coherent and we have fundamental conflicts within our culture, including the effect of technology, science, urbanization, etc. Conscience or the sense of ought arises when there is conflict between our personal inclination and the cultural norm, but conscience

itself is a social-psychological phenomenon and not a value.

In our efforts to solve a value difficulty, we ask the question, what will be the probable consequence? The consequences I am most interested in are those conditions that are essential to the having of values: not only the achievement of a particular value in a situation, but one which will fortify the conditions that make for the realization of other values. In considering a value problem, we can only determine whether it was good or valid in terms of its consequences.

Value norms are what I would call the conditions of effectiveness, those that give us power and control in the pursuit of values. Our basic values are essentially these conditions of effectiveness, and I would associate them with the conceptual constructs or postulates—Professor Margenau's c-field. They operate in value inquiry as postulates operate in scientific inquiry. Thus the fundamental postulate underlying moral action is that of respect for human life and personality. Respect for truth, for objectivity, is such a condition of effectiveness. The objectivity of science makes it possible for us to deal with the world on its own terms rather than in terms of illusion or confusion, and it is upon the congruence of public opinion with the nature of things that the success of democracy is fundamentally dependent. A third condition of effectiveness may be called by different terms, all pointing in the same direction: community, participation, mutuality. A fourth may be designated as order, organization, integration. Another is flexibility; another, universality or inclusiveness; another is enjoyment of beauty, and finally, there is creativity, or capacity for continuous growth.

Science will never be safe for the modern world, nor the world safe from science until the logic and temper of science become generalized in human affairs. Science in human affairs means that just as the verification of claims to truth are subjected to public and empirical tests, so also are claims to value subjected to public and empirical tests. This in the best sense of the word is the meaning of democracy.

Lecture XIII. Integration for the Process of Education, Dr. William Heard Kilpatrick, Professor Emeritus, Teachers College, Columbia University.

Philosophizing is the effort, by critical thinking, "to attain to a more ordered and intelligent happiness." The most practical and important thing about a man is his view of the universe. In building a philosophy, one tries to get an outlook which is consistent with itself and is so intelligently made that others can accept it and cooperate with you upon it. To do this, one must question what one grew up believing, for, unless one thinks things through for himself, he never has beliefs in any full sense for his own intelligent use.

Bertrand Russell has said that our duty "... to teach how to live without certainty and yet without being paralyzed by hesitation, is perhaps the chief thing that philosophy in our age can still do."

A philosophy of education must ask three questions: (1) What kind of civilization do we really wish our philosophy to build and uphold; (2) What kind of character and outlook upon life will best support this desirable civilization; (3) What kind of school life will best build this necessary character?

In discussing the first, we must believe that the life good to live for all people becomes the inclusive aim of civilization. There are two sides to the life good to live: (a) the sovereignty of the living individual as the unit of judgment and responsible action; and (b) the need to live together as members one of another. It thus follows that morality is a social necessity and that democracy is a way of life respecting human personality wherever it is found.

There are several basic concepts: (1) man is best conceived as a goal-seeking organism; (2) man's capacity for self-conscious direction lies at the basis of all human behavior; (3) change is inherent in human affairs (the more effectively creative men are, the more rapidly changes occur in human culture); (4) because of change, we face an uncertain future and we must have free play of intelligence (this is our finest and final resource); (5) probabilities furnish our guide for thought and action; (6) we need an inclusive outlook to guide us through a changing world — a philosophy based on change.

The kind of character needed to uphold the desired civilization should have these characteristics: (1) a normally adjusted personality; (2) practical common sense; (3) acting on thinking; (4) skill in constructive group discussion; (5) regard for the rights and feelings of others; (6) responsible citizenship with each committed to carry his fair share of what is to be done; (7) each must have a variety of interests and sources of finer enjoyment; (8) ideals, standards, and principles of action throughout life.

The educative process which promises best to build this sort of character is one based on seven principles: (1) we learn what we live; (2) each learns what he accepts as his way of living; (3) each one learns each item—thoughts, feelings, skills—in the degree that he accepts it; (4) whatever one is otherwise learning, he is at the same time thinking and feeling about what he is doing and is learning these concomitant thoughts and feelings; (5) one seldom learns a conception or an attitude all at once — it is a cumulative process; (6) each one builds his own generalizations — they cannot be given to him; (7) the doctrine of interest is the best single guarantee of success in all of these foregoing principles of learning.

We thus envisage a kind of education in which schools are thought of primarily as places of living, in which interests and purposeful activity set the pattern, in which personality is always so respected that as few compulsions as possible are employed, and in which the finest aims of life possible to the age of each child are the goals.

Lecture XIV. Panel Discussion, Dr. Margenau, Dr. Northrop, Dr. Axtelle.

Northrop: We might see whether we could identify some of these concepts in science, philosophy, and education that are integrative, by which I assume we mean concepts that are applicable in a number, and possibly in all, areas of experience and nature. It seems to me the beginning of integration is analysis. In analysis one has to separate out what is given by immediacy—pure fact—and what is given by inference and theory that is indirectly verified. In art, in science, and in all the different departments of education, it seems to me important that we separate these two modes of discourse.

Axtelle: Two questions: Is there a sufficient body of theory generally accepted in the various sciences which would suggest certain concepts that would be applicable? And would it not be a stimulus to the philosophy of science if the various sciences were to try to shape inquiries in such a way as to test, refine, or invalidate notions which seem to have wider currency than in just a single science? Such ideas or general theories as evolution, culture, organism, have applicability over a wide range of phenomena. Can more be developed?

Margenau: Mathematical theory is indeed a way to integrate, if we can only convince people at an early age that mathematics and science are nothing but a language that can be learned with joy and profit. In the light of mathematics such a theory as the complimentarity principle of Bohr, which states that certain aspects of an electron can be explained in terms of a wave, and others in terms of a particle, can become meaningful. In other words, particle and wave are not germane to the electron, and it has other properties which are consistent with one another, which no longer call for a dualistic interpretation.

Northrop: If I were asked to pick out the notion that will run through all realms of discourse it would be that of formal relatedness. Biological organization, if properly analyzed, may be found to be one instance of it. The gestalt is also an instance, but for that matter every scientific attempt can be said to be an instance of it. A particle in physics is no less a matter of formal relatedness than a gestalt theory. These relations call for terms of certain kinds under certain circumstances, and other kinds under different circumstances. There is no contradiction. The two kinds of relatedness should not be confused, however. The relatedness of impressionistic immediacy is not adaptable with the relatedness given with inductively formulated scientific knowledge.

A basic point is that with scientific knowledge you are not merely getting a theory of nature, but also a theory of nature of the individual as known. In scientific theory the individual has to start with the p-plane, the data, and by creative imagination, theoretical construction, set up postulates, deduce consequences from them, reason logically, and check them back. From this it follows that any knowledge, even if it is Marxist doctrine, presupposes inquiry of the individual, and thus the individual comes ahead of the doctrine and the theory of law has to presuppose and protect the freedom of the individual. Also, anything truly known is an instance of universal law, so that any truly known individual is equal under that law with all other individuals.

Axtelle: In the discussion after my lecture Professor Bogoslovsky made an important observation. He said reciprocally our value attitudes influence so much the nature of that we observe that our concept of man and of nature is itself enormously influenced by the value attitudes with which we approach man and nature. For example, when asked, "What do you think about the universe?", Marx would reply, "It is struggle." The point is that Marx was a fighter, and so he approached the world. Thus the relationship between facts and values is reciprocal.

Margenau: I would agree. The reason integration is important is that it determines emphasis. So far as part of our integration comes from immediacy, fact determines value. Insofar as part of our integration comes from the theoretical plane, theory determines value. The facts of immediacy do not themselves generate deductively any theories. The theories are purely created at the beginning in the logical sense. It seems to me that in ethics too there is a certain p-plane — domains for ethical observation, which are again explained by theories. Although science makes it possible to kill, there is nothing in science which tells me whether killing is right or wrong. I must have, in addition to the theories of science, commitment to certain specific ethical norms. In science we try to explain a given phenomenon by driving our theory back and back until finally we have to stop. It is the same with ethical concepts. They have to be tried out in scientific action. This is not relativism. Ethical behavior becomes good or bad only when judged relative to a set of moral rules. But these moral axioms are neither in harmony nor in disharmony with science. Morality in man must be tried with certain factors in experience and knowledge. If a man's experience has been nothing but strife, he will act as though that is the only factor in experience. He is good in the sense that he is acting in the light of a fact, but the perfect man is one who acts in the light of all the facts about the nature of himself and the world.

Lecture XV. Review & Discussion, Dr. Margenau.

At the end of the last session, the question was raised as to the difference between absolute and relative truth. It is said that the fine arts, ethics, the normative disciplines allow us to acquire knowledge that is absolutely certain, while the sciences, empirical as well as mathematical, are committed to a kind of knowledge that is only relative. It is my own belief that there is no discipline whatever that can claim the attainment of absolute invariability, ultimate permanent truth.

The sciences start with basic postulates, believed in earlier days to be self-evidently true. For many centuries this was accepted. Then about 1800 some scientists began to question the absolute truth of these axioms and the result was the discarding of this concept of their absolute truth. Today men have become aware of the doubtful status of axioms; they have accepted the simple fact that axioms are postulates which are assumed to be true in a tentative way, but which must gain their affidavits of validity by being confronted with empirical facts and by surviving this confrontation. Many people mistake the term "valid" for true. This, I feel, presumes a background of certainty which science cannot deliver. In science we always start somewhere with axioms, postulates, etc., and these are not true in the absolute sense of the word, but are as true as anything we have and know in science. Truth is a relative term.

Now we look at the other end of our quest. What about the immediacies of the p-plane? Are they absolutely true? To the extent to which the sensory experience is absolutely true, it is also absolutely trivial. If you merely assert the having of an experience, you are asserting a triviality to which we would hardly deign to attach the term "truth."

So we do not find absolute truth at either end of our scientific structure. It does not lie in the middle because every time you make a statement about empirical fact, a statement which is predicated upon theory and refers to matters of immediacy, you can certainly doubt the immediacies and you can also doubt the theories. Science is not a realm of absolute truth.

But in one sense it is. If I say that a triangle has three sides, I am saying something that in a sense is absolutely true. But it is really nothing but an explanation of what I have chosen to call a triangle. In other words, I a merely expounding a definition. Statements can be true, but again, this kind of truth is trivial. Let us beware of the claim that science tells ultimate truth.

What does science give us? It gives us not only something we can live by and act by, the best in the way of knowledge that we can possess, but it does more than that. Instead of handing us a stale bit of knowledge, something that is with us forever and which we never change, it presents us with a dynamism, a self-correcting progressing methodology which approaches truth.

What is the place of science in general knowledge? How does it fit into the totality of knowledge? Why do we call certain disciplines scientific? I think that we do so because the knowledge we have about them is structured in a different way from the looser kinds of knowledge which include our rules for action, our affective behavior, our emotions, etc. Science embodies all the principles of methodology which we have been discussing in this course. There is a strictness of discipline about scientific knowledge which most of the other kinds of knowledge do not have.

There is a school of scientists prevalent in sociology which thinks that as science progresses we are reaching the millennium. There will be a day when we understand everything, we arrange our lives, our social relations in accordance with rigid scientific rules. The immediate reaction to that proposition is one of revulsion, which I feel is not reasonable. I do not believe there is anything wrong with regulating things scientifically, things that can be thus regulated. We might have scientific understanding of something and yet be unable to regulate it. I do not think that the time will come when science can fully regulate our lives, because our knowledge is so vastly expanding that science cannot keep up with it.

Figuratively we might represent science by a crystal (which has a regular structure) and envision the crystal as residing and growing in an amorphous mass of heterogenous experience. The crystal will grow into other fields. It is now growing into sociology, into psychology, is making a big dent in zoology and botany, and a little dent into ethics. There are regions where it gives more structure to religion and if it does this, science is no worse off, nor is religion. If science were able to deal with religious things, they would be no less sacred. The mere fact that science might some day encroach upon a field that is now deemed literary, artistic, etc. and convert this field into something more clearly understandable and illuminated, does not constitute an indictment against science.

Many men now say that all knowledge is probable knowledge. We cannot have any sure knowledge. What is the difference between certainty and probability? Is there any kind of knowledge that can be expressed without probabilities?

May I use again the picture of the p-plane to illustrate what I have in mind? The immediacies, the raw material of science, never yield "true" values, in the sense of absolutely precise measurements. Scientists take a number of measurements, and then, using the theory of probability, emerge with a so-called "true" value. Anything you say about the world as it is must be couched and phrased in terms of probabilities. That is not true in the field of constructs. These hypothetical statements involve no properties, and are called deductive. Such theories are not probably true, they *are* true or false. But what the theories say about the world involves probability.

We see here how important it is to recognize the difference beween inductive procedures, which lie in the p-plane and deductive procedures, which lie in the c-field. For the latter we can get along without probabilities, whereas in the former we call upon the use of probabilities in a major way.

Another point which is frequently discussed is the old question of whether there is an intrinsic difference between the sciences and the humanities. In my opinion, there is no such difference. The reason for thinking such a difference exists is historical. The universities grew out of the scholae, frequently attached

to monasteries, founded to train ministers and priests, in which the teaching was done by Latin-speaking monks. The curriculum in them was called the liberal arts, which contained all the sciences known at that time. No conflict was sensed between the activities of an astronomer and those of a person who translated holy writ. They were all scholars.

A little later, cities sprang up in which the arts and crafts developed and the men did not speak Latin. They used the vernacular and for that reason were looked down upon by the scholars in the universities. In those days no distinction was made between a barber and a surgeon. They were all craftsmen. The architect belonged to the same guild as the stone mason. It was among this group that the new empirical science developed and finally swamped the culture.

I feel that if we could teach science in a liberating way and inject a bit of science and philosophy into our liberal arts courses, we could easily dispel the illusion that there is a barrier between these two fields.

SOURCE READINGS:

INTEGRATIVE METHODS AND MATERIALS

In this issue of MAIN CURRENTS we are able to begin in a modest way to implement once more the original program pursued by this journal. We publish the first source reading items which have come to hand since October 1st. In contrast with the year of the magazine's starting (1940), present numbers of passages significant for our purposes are smaller than formerly, no doubt in part because of security measures of all kinds, not merely restricted publication. The work will continue and the results may be expected to enlarge. We shall from time to time inform readers about coverage, and intend to thank contributors by name, at intervals.

For gratitude is certainly due to correspondents undertaking the scrutiny of the journals listed in MAIN CURRENTS (Vol. 9, No. 1, p. 17), and other sources which will be mentioned from time to time. Today's organization of the publication of learned articles makes immense coverage possible. But examination of Physical, Mathematical, Biological and other Abstracts is tedious, and recourse to the original source for amplification constitutes a good deal of work. We believe, however, that specialists will have real recompense in finding that their contributions enrich progressively not merely a repeating mosaic of accumulated data, but a rich and meaningful design, nature's orders and man's noblest creations. The Abstracts certainly constitute a major source of assurance that developments of philosophical interest will be for the most part caught up from the passing torrent of studies.

As noticed above, under notes on the Foundation's Cooperative Program, an increasing number of colleges are designating correspondents to keep them in lively touch with the work of the Foundation. As these representatives come on the list, the suggestion will be made to them and to such of their faculty colleagues as may be interested, to make use of MAIN CURRENTS along lines of its policy, as if it were their own journal or commonplace book, by acting as source readers and recording here what they can show is or is likely to be of enduring significance; and by joining in with us as book reviewers.* As each cooperating institution begins to make such use of the journal we shall together steadily enrich our storehouse of material for integrative developments in education.

The question of criteria for source reading properly comes forward. The following notes may here be useful; the subject will come up for reexamination as we proceed together.

We intend to keep readers informed about articles and books which embody the methodology which has been articulated by various writers who have examined for this purpose the development of physics taken as part of the history of thought.

For several years emphasis has been upon the deductive methods of physics. Recently increased emphasis has been laid by leading scholars upon what the application of these methods may imply for other sciences, particularly biology, psychology, social studies, and for the humanities. There is thus a new intellectual climate making itself felt which has in turn reflected itself in basic skills, notably linguistics and mathematics. It can hardly be maintained, however, that the effect even of all the changes manifest in physics, let alone likely

*Books for review will be sent to cooperating teachers, and our reviewers can also arrange to have books of their own selection sent to them. Upon request, especially while the Cooperative Program is taking shape, the Foundation will relay to publishers the name, address, and status of the intending reviewer.

prospective developments in other areas, has been as yet adequately embodied in teaching skills, and particularly in educational methods for teacher education. Nor have these gains been properly exploited in general education course offerings as integrative methods. As more and more material appears, we should report and evaluate it as part of a really decisive transition.

The headings to be kept in mind might be: method, as such, which can be used to improve the conceptual structuring of all knowledge, and which leads to better understanding of the knowing process; relevant developments in mathematics, linguistics, and other basic skills; specific conceptual gains in physics, biology, psychology, sociology, and anthropology, or data which may seem to call for such advances; main currents in all aspects of the arts and humanities generally; pertinent developments in educational theory and practice.

It may be desirable to focus thought for source readers by making some remarks upon the phrase above, "the knowing process."

We learn initially as children by doing, imitating, by being accustomed or trained. Such is the human situation, and no one can usefully quarrel with it. If training is unduly prolonged, however, the growth of the mind is stunted. Literacy all too easily can convert an excess into an evil, and confusion, fear, and indoctrination may all too readily follow. The democracies are in mortal danger because the prolongation of training is fostered in ignorance of any alternative.

Fortunately the cultural heritage and the very nature of man makes it nearly impossible for the most inept teacher to prevent conceptual thinking quite entirely. The mere use of language ensures a little exercise of the higher or abstractive mind, even if it does not guarantee any activation of creative imagination. But we must confess, if we are honest, that we do far too little of that teaching which will arouse in all citizens the maximum exercise of their minds, their souls, their spirit. Teachers have little defense against the pressures pushing them toward intensification of indoctrination, specialization, and conformism unless they can agree how they are to arouse conceptual thought and creative imagination.

The mere formulation and widespread use, however, of a good and currently sufficient scientific or even a correct and useful philosophical methodology, admirable and truly urgent as such an enterprise most certainly is, does not and cannot solve all problems. The essence of education is to reveal to, and evoke in, the student methods by which he can in turn unlock his own powers. To put the position with utmost economy: There are three somewhat unsettled questions: What is man and what does his existence mean? What is nature, and how did it come to be? How are these things related in a common universe?

It is patent that we are much too deficient in our basic knowledge to begin to close up any system of knowledge as if it were finished business. Consider sense perception alone, the very rudiments of learning, whether it be by training or by education. No one claims that he can explain how disturbances outside become sentience inside the living organism. A kind of despair may come over us when we consider how long we have suffered this particular fundamental deficiency, one among many. As a result of such basic frustration, biologists may write as if sentience doesn't exist, and some artists, perhaps even musicians, may act as if linear air waves don't matter. Or cynicism may overtake teachers and lead them to say that our knowledge is so defective that any old education is enough if it leads to technical expertness, accommodation into society, and a good automobile.

It seems clear that we must disseminate the best methodology which we have today for integration, and do the very best we can with the products of such methods in structuring knowledge, while searching diligently to improve the *basis* of cultural production, i.e., the knowing process, in all aspects, and to improve the organization of the products, i.e., to conceptualize the new knowledge that it may be passed on and not, as happens too often, left behind because it is not part of a meaningful whole.

Hence in source reading we may and should be guided by the important epistemology which the last eighty years of science has made possible, and which the Foundation for Integrated Education is helping to promulgate; but we are also called upon to watch out for the revolutionary discovery (in contrast with mere techniques and gadgetry), the rebel thought, the daring notion, the far vision, the lost art, which will enable us to improve the learning process itself as well as strengthen and simplify the body of significant knowledge.

INTEGRATION IN THE SCIENCES

Volume 80 of the *Proceedings of the American Academy of Arts and Sciences,* is a special series devoted to "Contributions to the Analysis and Synthesis of Knowledge." In No. 2 (1952), pp. 173-186, is an article by Laura Thompson entitled "Some Significant Trends Toward Integration in the Sciences of Man."

The article presents a selected bibliography of about 125 items first "to call attention to some trends in the human disciplines which appear to be especially significant regarding the eventual emergence of a systematic, unified science of man; and second, to illustrate the thesis by means of a limited number of references, especially to recent publications in the English language." The trends identified by Thompson are presented below but without the references and with some omission of explanatory material.

Trends Toward Integration in Theoretical Approach

1. *The sciences of man are natural sciences . . .*

2. *The significant unit of research in the sciences of man is a human event in space-time . . .*

3. *Significant problems in the sciences of man deal with the inner structural relations of an organized dynamic "field."* A significant tendency is to view the multidimensional human event in space-time as a dynamic "field" and to view the scientific problem as the discovery of the structural organization of this "field" . . .

4. *The trend, in terms of the present thesis, is away from investigating a human problem merely from a single viewpoint and toward perceiving the human event from many viewpoints simultaneously so that the relationships between its various aspects and its inner and outer form may be discovered.*

The above-mentioned trends reveal throughout the fundamental sciences of man, a convergence in basic theoretical approach which manifestly is related to recent trends in physics and mathematics, in logic, and in modern art and architecture . . .

5. *The new approach, especially concentration on multidimensional human events in space-time, on transactional relationships and on perception from many viewpoints simultaneously, together with the imperative need to solve practical problems, has necessitated the crossing of barriers between traditional academic disciplines dealing with mankind . . .* Although still in the formative stage, for purposes of this thesis [these key dimensions or vantage points] may be conveniently designated as follows: *the ecologic dimension*—society-nature transactions; *the somatic dimension*—somatic transactions; *the social dimension*—interpersonal and intergroup transactions; *the psychic dimension*—psychological transactions; *the symbolic dimension*—symbolic and semantic transactions including language, ceremonials, arts and crafts, music, mythology, folklore, sciences, etc.; *the core values dimension*—basic evaluational transactions. Parenthetically it should be noted that alongside the major divisions outlined above, attempts are being made in the direction of developing a more adequate philosophy of the science of mankind . . .

6. *Significant attempts are being made to investigate the inner structural relations between two or more of these basic dimensions of the emergent science of mankind . . .*

7. *The new approach has revealed the need of field methods and laboratory techniques of requisite precision and penetration . . .*

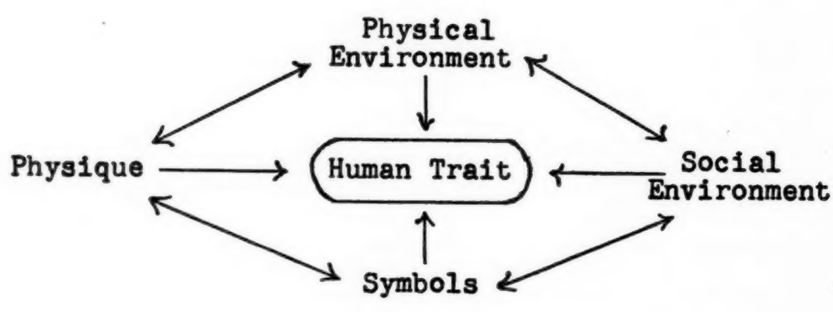
8. *The development of properly precise and penetrating methods and of multidimensional cross discipline research has necessitated a thoroughgoing revision of traditional concepts . . .*

9. *There is increasing interest in the formative processes whereby ego-cultural, social, and psychosomatic wholes are integrated, especially in the directiveness of organic activities, the purposiveness of individual, social, and cultural processes, and in human creativity . . .*

10. As an outgrowth of all these developments, *the crucial importance of basic, emotionally-tinted attitudes and core values is being more and more recognized in the life sciences and in practical everyday living problems. . . ."*

C. W. Morris in "The Science of Man and Unified Science," *Proceedings Am. Acad. Arts & Sciences.* 80 (1951) 37-45, takes a similar position when he identifies "a third growing tendency in the scientific study of man: the tendency to regard any particular human trait as a function of many factors or variables, i.e., to think in terms of fields." Morris indicated this point of view in the diagram below.

Morris notes further: "The constitutional and environmental factors link the science of man with the biological and physical sciences. At the same time, the recognition in personality development of the role of social factors and the role of symbols which individuals produce, ensures us that nothing distinctively human will be lost. The science of man is linked with the biological and physical sciences but not reduced to them."

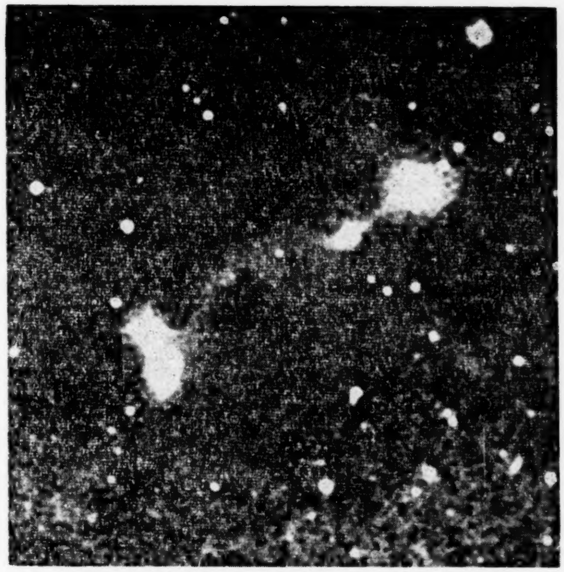


FOLK MEMORY AND HISTORY

The persistence of folk memory in societies without any recorded literature is well known to students of folklore. An instance is documented in a survey of tales and archaeological evidence that in the New World the elephant lived on into the time of the Indians: "Men and Elephants in America," by Ludwell H. Johnson, III, *The Scientific Monthly,* Vol. LXXV, No. 4, October, 1952, pages 215-221. For the evidence of this contemporaneity itself, the article is important, and the bibliography extensive. It is, however, to the matter of folk memory which we direct attention. That whole subject was summarized by Andrew Lang in a remark that tradition is as fluid as water and as tough as steel. For support of the validity and significance of this judgment, we quote from the article mentioned in a paragraph from page 216, and the concluding paragraph from pages 220-221, inviting particular attention to the last two sentences:

"There can no longer be any reasonable doubt that man and elephant coexisted in America. A century's accumulated evidence has recently received a decisive addition which established this fact beyond question. In the vicinity of Tepexpan, Mexico, one of many excavations in that area brought to light the bones of an imperial mammoth with projectile points in the ribs and with stone knives and scrapers close by. First estimates placed the age of these remains at from 11,000 to 16,000 years (*Life,* 32, 36, Mar. 31, 1952) but later carbon 14 datings give an age of about 18,000 years. Still later estimates based on soil data strongly indicate that this mammoth met its end well back in Wisconsin time, during the last glaciation."

"Archaeology has proved that the American Indian hunted and killed elephants; it has also strongly indicated that these elephants have been extinct for several thousand years. This means that the traditions of the Indians recalling these animals have retained their historical validity for great stretches of time. Exactly how long, it is impossible to say: probably the minimum is three thousand years; the maximum may be ten thousand or more. If some Indian traditions have remained historical for so many years, undoubtedly traditions of other races and peoples have also. Direct historical record of the past is usually thought of as extending no farther back in time than the beginning of writing, but, once it has been demonstrated that very ancient folk tales may have a high factual content, the sources available to the historian and anthropologist are increased tremendously. This field of research holds great possibilities for increasing man's knowledge of the past."



This photograph from the 48-inch schmidt telescope at the Palomar Observatory of the California Institute of Technology was enlarged 17 times from the original plate. (Mount Wilson and Palomar Observatories Photo.)

BRIDGE BETWEEN GALAXIES

In *Publications of the Astronomical Society of the Pacific,* Vol 64, No. 380, Oct. 1952, pp. 242-246, Dr. Fritz Zwicky, Professor of Astro-Physics, California Institute of Technology, discusses the star streams which have been recorded by sharp contrast photography, that connect some and perhaps all galaxies, and make a netted filamentous system out of the universe. A typical greater distance known now to be thus spanned may run to 72,000 light years. The connections between double nebulae have been noted before. The delineation of the amount of matter in them, and in cosmic dust, may revise cosmological theories, especially in respect to inter-galactic distances and megogalactic dimensions. This is still uncertain.

THE LAW OF SINGLE VARIABLE

A paper of major import, "New Concepts in Education," by Stuart A. Courtis, presented before Section Q, Education, of the American Association for the Advancement of Science, Cleveland, December 27, 1950, was made generally available in the *Journal of Educational Research,* April, 1952, pages 571 - 584.

In diagnosing the ills of the "science of education," the author says (p. 571):

"One of the early steps essential to a mature science in any field is the objective definition of elementary concepts; a second is the observance of the Law of Single Variable in all experimentation. We psychological and educational scientists, in spite of warnings by James and others, have been content merely to postulate elements such

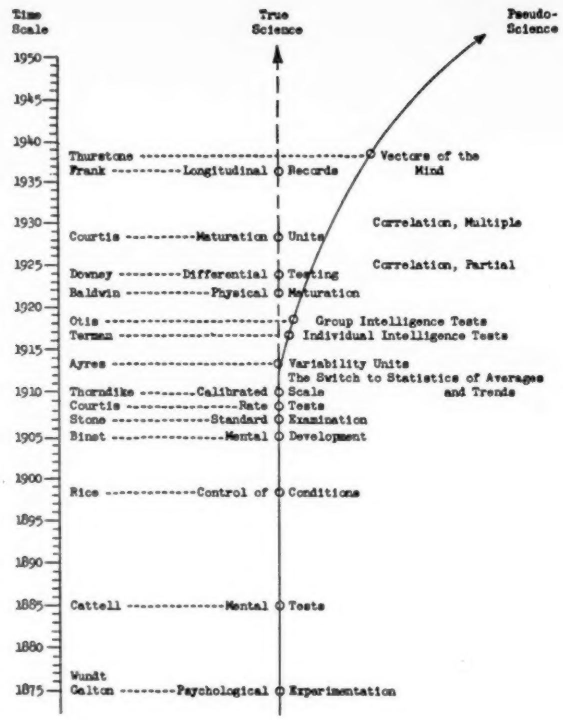


Figure 1

Where Science in Education Went Astray

(From the Journal of Educational Research, April, 1952)

as 'intelligence,' and have been very uncritical of our weak attempts to observe the law of the single variable. Our control experiments never have groups which are proved equal in rate of growth *before* the experimental factor is applied. As a result we are today in possession of mountains of quantitative data whose interpretation is not furthered by our experiments, and we have discovered no laws as the exact sciences know law. We possess only large masses of qualitative conclusions nearly worthless for purposes of prediction."

Of tests and measurements, the author says (p. 573):

"Unfortunately, scores in tests are neither comparable nor measures of specific elements. When treated by statistical techniques devised for comparable measures of specific elements, the results are, of course, invalid. Consequently, all conclusions based upon such invalid processes and data are equally invalid. Indeed, the effort and money expended on tests and measurements have been worse than wasted. For they have created patterns in our thinking which will be very difficult to remove. Our infant science will have to burst the restraints of its swaddling clothes—deductive postulation of elements and inappropriate statistical techniques of analysis—before further growth is possible. Fortunately, this it is beginning to do and there is hope that it is about to enter a new, and more productive, cycle of development."

A testing technique is described which seems to deal with an elemental entity in psychology comparable with such elements as mass or temperature in physics, according to the author. His preliminary experiments indicate that it is "probable that the isochronic scores measure the quality of the individual, differences in ability to profit by experience; native capacity to you."

The article concludes with a list of new concepts "objectively defined on the basis of experimentation under the law of the single variable": elements, the level of maturation achieved, incipiency, rate of maturation, maximum, cycle, quality, potency, and complexity.

NEWS AND NOTES

The process of converting general education programs into conceptually integrative studies is complicated and beset with valid administrative and practical difficulties. It can be facilitated and brought to earlier fruition only by the concerted action and cooperative efforts of faculty members not only on their own campuses but among widely-scattered colleges in a variety of academic situations.

Obviously, final decisions as to program must be made by administrations and curriculum committees. To make these decisions and to formulate the necessary changes in policy, everyone must be fully informed. Administrators cannot do this alone and in a vacuum nor can any given curriculum committee come up with a full-fledged, effective program which can be relatively sure to avoid the inherent difficulties unless they are aware of the manner in which these problems have been met elsewhere. Hence, the Cooperative Program can not only be a sharing of experience and experiment among colleges but can *and should* be viewed as a venture which involves every faculty member everywhere. Moreover, it is the stu-

dent who, by his response to the teacher's efforts in his behalf, is not only the final judge and demonstrator of the effectiveness of a method but is also capable of having ideas and insights of his own. Hence student interest and aid in the development of integrated programs should be highly valued.

There is no faculty member in any department who cannot contribute to the growing body of diversified material which the Foundation is accumulating. Discussion of experience in integrative efforts can and should be shared by all. The introduction of a methodology standard is essential but is not easy as institutions of higher education are presently organized. But such a methodological standard or criterion must be introduced, and it is the experience of the faculty member (and his students) which can help in its development.

From the beginning, Foundation policy has emphasized the primary role of method. If any method for achieving conceptual enrichment of a course or curriculum is to have effect, the curriculum group and the faculty members are called upon to discuss, to agree upon it, and to take steps to implement it speedily.

There are already many college programs which are intended to promote integration. Administrators, curriculum committees, and faculty members should inform themselves of these in order to arrive at one which best suits the needs of their program and student body. It is one of the aims of the Cooperative Program to provide this data to the subscribing institutions.

In referring to method, the Foundation points to that which has been so dramatically demonstrated in the sciences of this century. Briefly, it is that process involving the subtle imaginative construction of concepts which can be tested empirically for their correspondence with the empirical data of observation and experience. Integration, using this method, is a process by which valid concepts and not the factual minutiae in all fields comprise the datum or frame of reference basic to an education.

But a consensus of curriculum groups, administrators, and faculty upon such a method involves study and discussion by representatives from all departments and disciplines.

The Foundation is itself developing a program of studies which is represented by a growing body of diversified material yet to be published. As more experience in conducting courses is acquired and as the lectures, source materials, and bibliographies used in these courses become available, an increasing amount of tested material is ready for the assistance of curricular groups. These materials are forcing a re-evaluation of our judgments as to the conceptual nature of the learning process generally and the role of imagination and other creative aspects in science. The revolution in physics brought about by new concepts demonstrates the power of this process, the implications for biology are becoming clear, and the vistas opened for advances in the science of man, the social sciences, and the humanities are vast.

Teachers are aware of these events, and courses of study which describe and exemplify the revolution are quite commonly offered at various levels. But the generalization into other fields beside the physical sciences is just begun and cannot be provided in "neatly packaged" form. Even if it could, canned goods are not so vital as fresh fare.

If the educational process, and the training of teachers, is to benefit adequately, basic studies of method and general applications must be made. From such efforts the needed documentation will accumulate, and the research required can be identified and implemented.

Experience indicates that there is scant hope at present of setting up an adequate body of educational materials without experiment and explorations in courses of study which will evoke it. This takes time, as things now stand, and the substantial expenditure by funding sources which would accelerate these studies is not available. Hence the slow but steady progress in the Foundation's courses together with the shared findings of every interested educator and institution must serve as the principal source of new experience.

The Cooperative Program is designed to provide a means whereby the available materials and the consultative services of the Foundation may become available to institutions of learning.

Each institution should designate one member of its curriculum committee to be its correspondent in the Cooperative Program. It is now proposed by the Foundation to develop an advisory group which will be composed of these institutionally-appointed correspondents. This group can materially assist in the guidance of the future outworkings of the program.

Foundation staff and Council members are prepared to aid subscribing institutions and their faculty groups in every way possible and will gladly confer with them when needed.

Summer workshops can and should be of such a nature as to suit the needs of cooperating groups. Cooperation in developing these workshops is hereby solicited.

But individuals, whether they be administrators or faculty members, should not feel impelled to await the formal action of their administration. Those to whom the principles forwarded by the Foundation are new or obscure owe it to themselves, their students, and the culture of which they are a part to inform themselves of them.

While institutional correspondents should most certainly be thoroughly familiar with all of the materials of the Foundation, individual faculty members should no less certainly read and discuss with their fellows and share with their students the contents of MAIN CURRENTS IN MODERN THOUGHT,

which, of course, ought to be in every college library. These are means whereby everyone involved in the educative process can aid in the creation of an atmosphere and the development of a consensus in which curriculum committees and administrators can properly study integrative programs and make such adaptations of the methodology as best suit their institution's needs.

But there is even more that the individual educator can do. Either from his experience as a teacher or his mastery of his particular special subject matter, he has much to share and this the Foundation welcomes him to share. In the former instance, he can contribute to the discussion of methodology. In the latter, he can increase the flow of those conceptual materials into the "main currents of modern thought."

The program ahead is long-range. The amount of work yet to be done is enormous.

A broadcast in Italian, entitled "An Integrative Point of View of Physics, Psychology, and Biology," was made on October 17th over the Italian network in the *Radio University Program,* which is a weekly contribution of the Italian Service of the Voice of America to *Universitá Internazionale Guglielmo Marconi.* This cultural program of the Italian radio, to which also the Italian Universities, the British Broadcasting Company, and Radio Diffusion Française contribute analogous lectures of scholars of these countries, is broadcast three times a week through the entire Italian network. An earlier lecture by Mr. F. L. Kunz, on the work of the Foundation, was made over this series in 1951.

Dr. Margenau's lecture was based on a summary of two talks, "Mechanism and Space-Time" and "The Breakdown of Mechanism," originally given in 1951-52 in the New York University course, "The Frontier of Knowledge: Integrative Concepts in Science, Philosophy, and Education." The program was prepared by Dr. Giorgio Tagliacozzo, of the Italian Service, Voice of America.

Texts of this broadcast are printed and distributed to Italian universities, research institutions, and libraries, as well as to a large mailing list.

The Philadelphia course in integrative concepts now has a registration of 150 people and an analysis of 115 of these who have replied to a questionnaire as of this date shows that 33 are active in education, 17 are in engineering, there are 2 chemists, 1 bacteriologist, 1 physicist, 2 pharmacists, and 2 clergymen.

The field of major interest of 27 of the group is physics, chemistry, engineering, or mathematics. Nine in addition are interested in electronic calculators and servile mechanisms. Seventeen are interested in the biological sciences and medicine.

Only 18 of the group have no college education, 38 have bachelors degrees, 31 have masters degrees, and there are 14 doctors (Ph.D., M.D. or D.Ed.). Although the alma mater was not asked in the questionnaire, we know that we have 16 graduates from the University of Pennsylvania, 7 from Temple, 5 from Harvard, 5 from Columbia, 3 from Haverford, 3 from Mount Holyoke, 3 from the University of Minnesota, 3 from Smith, 2 from Bowdoin, 2 from Pennsylvania State, 2 from Chicago, 2 from Bryn Mawr. There are 1 each from Amherst, Antioch, Goucher, Indiana University, Massachusetts Institute of Technology, New York University, Oxford, Swarthmore, Syracuse, University of Michigan, Purdue, Radcliffe, University of California, California Institute of Technology, and Vassar.

Thirty-seven had their most recent formal education within the past 5 years, 54 within the past 10 years, 70 within the past 15 years.

Only 18 of the group reported having taken no formal collegiate sciences, but 36 of the group had no formal college courses in philosophy or the social sciences.

The interest manifest in the first seven sessions of the course has been great and desire has been expressed by many that the discussions be supplemented. To this end three additional sessions of the course have been scheduled to be devoted exclusively to discussion. The first will occur on January 28, when the concepts and material presented in the entire first term will be considered. The second will be held on April 8, when the first nine lectures of the second term will be brought into review, and a final seminar on May 27 will cover the material of the entire course. By this means the Foundation is attempting not only to make the course itself more valuable, but to explore the techniques whereby such courses can be augmented by discussions of this nature from the participants in the absence of the lecturers themselves.

The series of three lectures which the Foundation will give in affiliation with the Staten Island Institute of Arts and Sciences, and which was announced in the last issue of Main Currents, has been entitled, "Mind, Matter, and Life." The series will consist of "The Expanding Self in the Growing Body," discussing modern concepts in developmental psychology and psychosomatics, by Harvey W. Culp, the Foundation for Integrated Education, December 3; "Patterns of Life," by J. T. Bonner, Princeton, discussing modern concepts in biology, particularly as regards the cell and morphology, January 7; and "Modern Concepts in Physics," discussing the decline of mechanism and materialism, by Henry Margenau, Yale, February 11. This series is the Foundation's first attempt to present a very brief series of lectures sampled from the larger courses of integrative concepts.

Dates of publication of Main Currents have been changed so that all four issues will now be brought out during the school year, in September, November, January, and March. Formerly, Main Currents was issued quarterly.

REVIEWS

For many years, we who have been concerned with education have felt that something was sorely amiss in the teacher training programs by which those vital catalysts of individual lives, of society and the entire future of our history—the teachers—have been prepared. We have inveighed against a variety of educational philosophies and have pointed to obvious lags between burgeoning new disciplines on one side of our campuses and the failure to bring them into our schools through trained teachers on the other.

This situation is reviewed in a most scholarly manner by Harold Rugg in *The Teacher of Teachers* (Harpers, New York, 1952, $4.00). For centuries, says the author, our culture has been split between the Practical Tradition and the Great Tradition. The leaders of the two factions are, obviously, the Practical Men and the Creative Men, respectively. Jointly these two traditions have built the physical structure of modern civilization, but leadership, Dr. Rugg avers, has gone to the Practical Man because he has been regarded as safe and efficient. The Creative Man has been tolerated as a "follower and echoer of his superior." Remember how few really trusted a "Brain Trust"?

"Theoretically, in a democratic society," says Dr. Rugg, "the Teacher of Teachers should prove to be a man whose resources match the penalties of leadership. In a dynamic society he is the chosen change agent, the clear guide for the culture-molding process . . . But actually, in our society, matters have turned out otherwise. Instead of leading, he is following."

Thus it is that our great teachers colleges have been caught in the "conforming way" in a complex manner, involving politics, economics, philosophy, and just plain short-sightedness. This process by which teacher education was improvised along conformist lines from 1890 to 1920 is thoroughly documented. In fact, this book may well be said to be a source book of educational history and philosophy.

Distinguishing between Practical Men as *men of percept* and Creative Men as *men of concept*, Dr. Rugg traces the vast conceptual changes that have come to pass by virtue of the creative work done since 1920. But practical men have forged ahead with the industrialization of life and the promotion of new technologies with scant regard for their culture-wide implications and their impact upon human life and values. We stand within the age of atomic power and on the verge of another, soon to come, when most heavy industry will be reliably operated *without men*. A broad vista opens which will either mean a brave new world of peace and human progress or one of terror, disaster, and dictatorship. The next twenty-five years will bring either to pass. Time is running out and in that brief span "the supreme need will be imagination, based on encyclopedic knowledge of the new university disciplines. Not skill, not efficiency, not even inventive ability will suffice. The building of technical know-how . . . will take second place . . . Among the men of imagination the Teacher of Teachers will be called upon to put his talents to work far beyond the conventional fields of education."

When teachers colleges were being formed at the turn of the century, no attention was paid to the social foundations of education,—first, because sociology was just being formed and, secondly, because "culture" was treated of abstractly, if at all. The historical foundations of education, according to Dr. Rugg, have been concerned exclusively with factual information and systematic chronology which often failed to relate past and present and to indicate the meanings of historical generalization.

In the 1890's there was no organic biology beyond the pioneering of the Europeans. Pavlov and Bechterev had just announced their first studies; Cannon was still reaching for the concept of homeostasis. Freud and many others were just getting down to their work. Thorndike was the first to receive the title of Professor of Educational Psychology, and his works, including his *Educational Psychology* (1913-1914) became the "bible" for the bio-psychological foundations of education. This theme has been "completely out of step with the major shift in thought from mechanism to organism that was transforming the sciences and the arts."

Rugg concludes that there were no aesthetic foundations of education in the period 1890-1920 and that this area has never been developed as an integral part of teacher education.

The philosophical foundations of education were in chaos and later became dominated by Dewey and Kilpatrick, who dominated the field until just recently.

The author amasses an imposing list of new concepts in new university disciplines which were emerging (but were not used in teacher education) during the very years 1890-1920 in which the first materials for formal teacher education were being improvised. These constituted a second intellectual revolution and could have put teacher education on the creative path instead of the conformist way.

The listing of concepts and discoveries and the author's discussion of them is too vast to be considered in a review. Certainly the period since about 1920 has produced quantities of creative materials for the social, bio-psychological, and aesthetic foundations of education to make a truly integrated program of education possible at once. This case is well documented and the evidence is convincing.

In a final section of the book, Dr. Rugg moves out to the "Frontiers of Theory and Practice in Teacher Education." Here he states the case for concepts and integration. Rugg's structuring of creative teacher education (and *all* education for that matter?) on conceptual lines, from "super-primary key concepts" outward, forms the core of a theory and practice of education which extends far beyond the confines of the classroom or campus.

In unison with an ever-increasing band, Dr. Rugg cries out for creative imagination in education and in life and joins with them (and us) in warning young

teachers, "Your concepts must be primary and right. Time is running out . . ."

In conclusion, we wish several things: (1) that it were possible to give an adequate review of this book; (2) that every present and future teacher and school administrator shall take inwardly to heart the excitement and challenge which it affords; (3) that it were possible to possess and master the "selected library for the teacher of teachers" given in the appendix; and (4) that we, collectively, will not fail to live up to the opportunities and challenges which the author sees as being America's in the crucial immediate future.

Seven years ago, the Harvard Report on *General Education in a Free Society* devoted attention, among many things, to the teaching of science to the nontechnical or liberal arts student. Criticism was made that the common instruction in science consisted of courses in special fields, courses which were devoted to developing a technical vocabulary and technical skills and to the presentation of accumulated fact and theory which the special science had inherited from its past. Specifically the report stated that in these courses "comparatively little serious attention is given to the examination of basic concepts, the nature of the scientific enterprise, the historical development of the subject, its great literature, or its interrelationships with other areas of interest and activity."

Under its general education program, Harvard has been teaching physical science to its undergraduates in general education with these criticisms specifically in view. One of the men who has been doing this teaching, Gerald Holton, has now given us a book, *Introduction to Concepts and Theories in Physical Science* (Cambridge, Mass., Addison-Wesley Press, Inc., 1952, $6.50) which brings the materials of this course together in a new type of science text. The book is dedicated to a presentation of the fundamental concepts and theories and concentrates on the meaning and power of basic ideas. The author states his purpose to be "Above all . . . the presentation of science as an *experience,* as an integrated and exciting intellectual adventure."

In its more than 600 pages this excellently illustrated book leads the student from experiment to experiment, from demonstration to demonstration, from ancient Greece to the flowering of modern physical science. History and philosophy are introduced, and the author has achieved to a remarkable degree his three aims for their introduction; to prepare an appropriate setting in which a particular idea came to have meaning; to provide insight into sources, motivations, and methods of approach of the founders of science, illustrating the human triumph behind the bare abstration; and to present science as one facet of the great quest for knowledge.

This reviewer believes that the student, given the proper academic environment and with personality factors being right, will indeed possess those things for which the author hopes: "[possession of knowledge of] the principal laws and the evolution of key conceptual schemes . . . [and it is hoped that] . . . as a responsible citizen [he] will understand the criteria of validity in modern scientific thought, the conditions that aid the fruitful growth of science . . ."

The twenty-five chapters are divided into seven very logically mapped-out parts. Beginning with an introduction of physical science in its historic context by the study of "motion" (Galileo: *"ignotato motu, ignoratur natura"*), proceeding to the study of *force* and Newton's laws, the text continues to apply the tools, concepts, and theorems of the first two parts to the astronomical contributions of Kepler and Galileo and to an analysis of the "genesis and power of Newton's crowning achievement" of the law of universal gravitation. In mid-passage, with this historical and conceptual background, the author devotes three chapters to "Structure and Method in Physical Science" ("Concepts," "The Growth of Science," and "Laws"). Continuing, the fifth part is devoted to the laws of conservation of mass, of momentum, and of energy, bringing in the work of Lavoisier, Huygens, Mayer, and Joule. The method by which this text escapes from strictly historical, factual, and philosophical *culs de sac* is beautifully shown at the conclusion of the section by the inclusion of the less obvious applications of the law of conservation of energy to "the human body as an engine," photosynthesis, and the origin of the solar system.

Many of us who have had to take physics and chemistry as separate disciplines in college may look with envy upon the present-day student who uses this text, for, in Part F the author conceptually integrates the two by presenting the origins of the atomic theory in physics and chemistry. This is done neatly by starting from the early work on the physics of gases and heat, leading by way of Dalton and Avogadro to a consideration of Mendeleeff's periodic table. Even here the student is not left bewildered with an inert *fact* in his hands, for the chapters not only go on to bring Mendeleeff's table up to date in its present-day form but point out the analogies between the harmonies implicit in it with those in Keplerian mathematical harmony in planetary motion. The stage is thus set for the author or teacher to proceed with a discussion of the kinetic-molecular theory of gases (which includes modern problems of gas diffusion of light and heavy isotopes) and on into the next part (G), which is devoted to "Quantum Theory and the Nuclear Atom."

We who have grown up under separated special disciplines have difficulty conceiving the relationships between electrostatics (in physics) and atomic structure (both in physics and chemistry). Yet, here in this section of the text a perfectly natural integration of the two is developed which includes excursions into Coulomb's laws, the electrostatic field, potential, etc. Light (usually the private domain of physics and having no apparent relationship to the atomic theory) also is fitted in so as to lead logically, after a discussion of the spectrum, to Planck, the quantum, and Einstein's photon theory. Radioactivity is presented along with a discussion of isotopes so as to lead up to Rutherford's nuclear model and so on to Bohr's atomic model, with its conceptual consequences.

The book includes five useful appendices and a good index. Many problems are given, with answers in the back of the text.

Not only should teachers and administrators look into this volume with its possible adaptation in view, but all of us who are interested in constructing or taking courses in integrative concepts can use it with great profit. It just goes to show that, even in the matter of writing text books, new concepts can do wonderful things to writing and the arrangement of materials!